

Daily report

20-04-2020

Analysis and prediction of COVID-19 for EU-EFTA-UK and other countries

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Foreword

The present report aims to provide a comprehensive picture of the **pandemic situation of COVID-19** in the EU countries, and to be able to foresee the situation in the next coming days.

We employ an **empirical model**, verified with the evolution of the number of confirmed cases in previous countries where the epidemic is close to conclude, including all provinces of China. The model does not pretend to interpret the causes of the evolution of the cases but to permit the **evaluation of the quality of control measures made in each state** and a **short-term prediction of trends**. Note, however, that the effects of the measures' control that start on a given day are not observed until approximately 7-10 days later.

The model and predictions are based on two parameters that are daily fitted to available data:

- ✓ α : the velocity at which spreading specific rate slows down; the higher the value, the better the control.
- ✓ K : the final number of expected cumulated cases, which cannot be evaluated at the initial stages because growth is still exponential.

We show an individual report with 8 graphs and a table with the **short-term predictions** for different countries and regions. We are adjusting the model to **countries and regions** with at least 4 days with more than 100 confirmed cases and a current load over 200 cases. The **predicted period** of a country depends on the number of datapoints over this 100 cases threshold, and is of 5 days for those that have reported more than 100 cumulated cases for 10 consecutive days or more. For short-term predictions, we assign higher weight to last 3 points in the fittings, so that changes are rapidly captured by the model. The whole methodology employed in the inform is explained in the last pages of this document.

In addition to the individual reports, the reader will find an initial dashboard with a brief analysis of the situation in EU-EFTA-UK countries, some summary figures and tables as well as **long-term predictions** for some of them, when possible. These long-term predictions are evaluated without different weights to data-points. We also discuss a specific issue every day.

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(0) Executive summary – Dashboard

Global EU+EFTA+UK trends and needs

In 1 or 2 days, EU+EFTA+UK countries will reach 1 million cases. Despite the magnitude of this value, the number of diagnoses will keep increasing. **Spreading rate ρ is fluctuating around 1**, today with an increasing trend. The epidemic is still not controlled, despite the mountain chain shows a decreasing tendency. The threshold of 100,000 deaths has been overcome.

The oscillations in new cases (i.e., peaks in the mountain chain) and, therefore, in ρ , show a period of 7 days. One could expect these oscillations to be related with incubation period of the disease, for

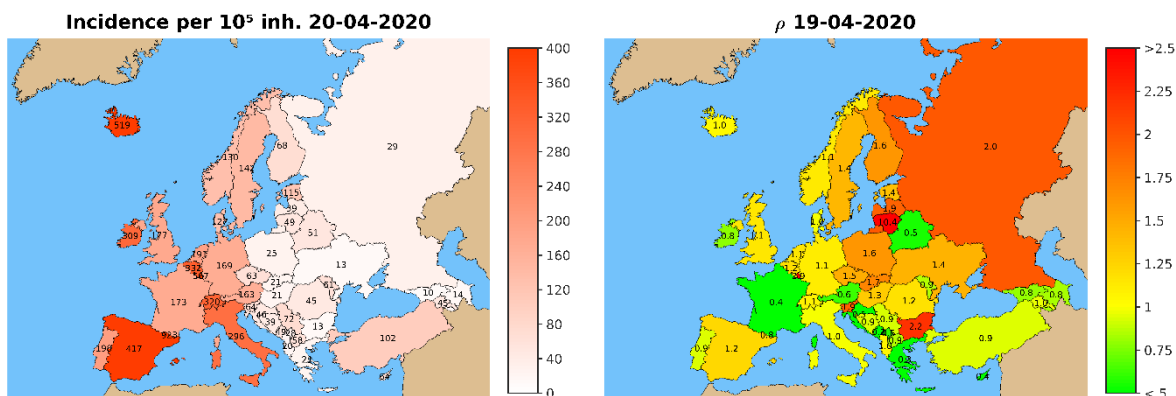
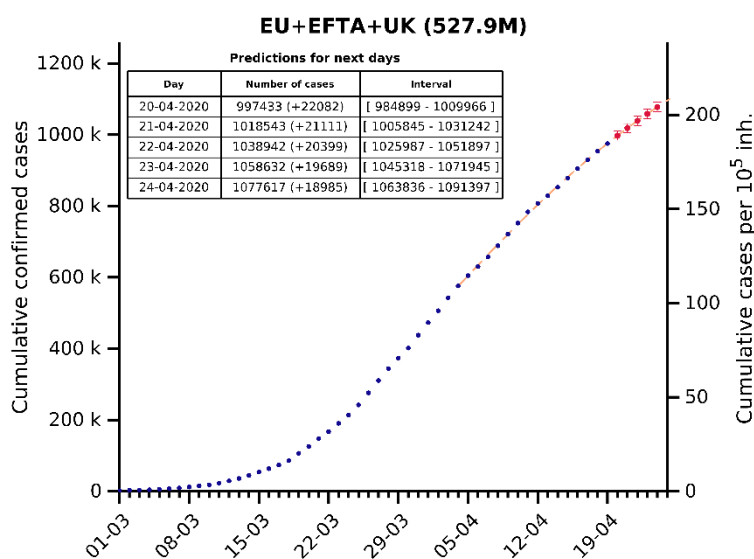
instance, but the reason is probably much simpler: **weekend effect**. In many countries, a decrease in new cases is usually observed in weekends, despite it is observed two days later in global databases because of reporting delays. These oscillations are coupled and thus seen at the EU scale. The precise reasons behind such weekend effect should be explored. In fact, two major sources for this effect can be mentioned. First, a simple administrative delay on recording case data. Second, and more worrying, a worse medical attention in hospitals because of a decrease in sanitary workers.

The analysis section of today's report is focused on analysing case fatality rate (CFR) of countries and its relationship with lethality and with diagnosis percentage.

Trends for specific countries

UK is the country with a highest increase in absolute numbers, with 5,500 new cases and a high EPG. **Spain** is still leading the rank in cumulative cases, with more than 196,000, followed by **Italy** (almost 180,000) and **Germany** (142,000).

There are several countries with $\rho > 1$, while a few days ago they had $\rho < 1$. This phenomenon is due to the coupled oscillations above-mentioned. If we focus on 3-day average ρ , **Lithuania**, **Slovakia** and **Bulgaria** show worrying values (4.97, 3.71 and 2.48, respectively). These countries still have low 14-day attack rate, but they should be closely watched out, because their situation could progress rapidly towards a critic scenario. Situation in **Luxembourg** is confusing, since they report high 14-day attack rate and a ρ of 2.09; nevertheless, these numbers could be related with a high percentage of diagnostic.



Situation and trends per country

Table of current situation in EU countries, according to data published by ECDC on April 15th. Colour scale is relative except when indicated, this means that it is applied independently to each column, and distinguishes best (green) from worst (red) situations according to each of the variables.

Country	Reported data						Indexes		
	Cumulative cases	Attack rate /10 ⁵ inh.	Cumulative deaths	Mortality /10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate /10 ⁵ inh.	Mean $\rho^{(1)}$	EPG ⁽²⁾	EPG2 ⁽²⁾
Spain	195,944	422.8	20,453	44.1	65,185	140.6	1.17	164.2	191.6
Italy	178,972	301.1	23,660	39.8	50,024	84.2	0.89	74.8	66.4
Germany	141,672	173.0	4,404	5.4	46,281	56.5	1.14	64.3	73.1
United Kingdom	120,067	180.7	16,060	24.2	72,261	108.8	0.92	100.4	92.7
France	112,606	174.0	19,718	30.5	42,128	65.1	0.59	38.4	22.6
Belgium	38,496	338.9	5,683	50.0	18,805	165.6	1.06	175.8	186.7
Netherlands	32,655	192.2	3,684	21.7	14,804	87.1	0.98	85.2	83.2
Switzerland	27,658	322.7	1,134	13.2	6,636	77.4	0.86	66.5	57.1
Portugal	20,206	194.8	714	6.9	8,928	86.1	0.87	75.3	65.8
Ireland	15,251	322.7	610	12.9	10,140	214.6	0.92	196.4	179.8
Austria	14,710	168.8	452	5.2	2,727	31.3	0.58	18.3	10.7
Sweden	14,385	146.2	1,540	15.7	7,555	76.8	1.42	108.7	153.8
Poland	9,287	24.3	360	0.9	5,185	13.6	1.29	17.5	22.6
Romania	8,746	44.2	434	2.2	4,882	24.7	1.09	27.0	29.5
Denmark	7,384	129.3	355	6.2	3,015	52.8	1.05	55.4	58.1
Norway	7,068	131.7	154	2.9	1,428	26.6	1.09	29.0	31.5
Czech Republic	6,787	64.0	188	1.8	2,200	20.7	1.17	24.3	28.6
Finland	3,783	68.7	94	1.7	1,856	33.7	1.34	45.1	60.3
Luxembourg	3,550	616.3	73	12.7	746	129.5	2.09	271.3	568.2
Greece	2,235	20.0	110	1.0	500	4.5	0.22	1.0	0.2
Hungary	1,984	20.3	199	2.0	1,240	12.7	1.19	15.1	18.0
Croatia	1,871	44.4	47	1.1	689	16.4	0.54	8.9	4.8
Iceland	1,771	486.2	9	2.5	285	78.2	0.86	67.6	58.3
Estonia	1,528	116.5	40	3.0	431	32.9	1.23	40.4	49.8
Slovenia	1,330	64.0	74	3.6	333	16.0	1.43	23.0	32.9
Lithuania	1,326	45.6	36	1.2	515	17.7	4.97	88.0	437.3
Slovakia	1,161	21.3	12	0.2	676	12.4	3.71	46.0	170.7
Bulgaria	915	12.8	43	0.6	384	5.4	2.48	13.4	33.1
Cyprus	767	65.6	17	1.5	321	27.4	0.56	15.3	8.5
Latvia	727	36.9	5	0.3	194	9.8	1.13	11.2	12.6
Malta	427	99.5	3	0.7	193	45.0	ND	ND	ND
Liechtenstein	82	212.7	1	2.6	4	10.4	ND	ND	ND

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500.0	500.0
Best	Best	Best	Best	Best	Best	Best	0.0	0.0	0.0

⁽¹⁾ Disclaimer: parameter ρ is very sensitive and experiments daily variations. Mean ρ is averaged per 3 consecutive days, but it can still vary the following days. ⁽²⁾ EPG stands for Effective Growth Potential. It is obtained by multiplying attack rate per 10⁵ inhabitants of last 14 days (i.e. density of cases) by ρ (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG2 is a similar index but attack rate of last 10 days is multiplied by ρ^2 .

Highlights for countries with highest number of reported cases

- ✓ Spain is revising temporal series of a few regions. In addition, some changes in data reporting protocols have been made. **Both issues may temporally affect Spanish data and predictions.**
- ✓ Short-term predictions for these countries are at the range of 5,500 daily new cases (UK), 3,500 (Spain), 3,200 (Italy), 2,000 (Germany) and 1,900-1,200 (France).
- ✓ Lowest 3-day average ρ corresponds to France (0.59), although the drastic increase in French CFR suggests a problem on data reporting. Remaining four countries are oscillating around 1.

Analysis: Case fatality rate of COVID-19 and 1% lethality as a reasonable scenario.

Reported number of deaths per 100,000 population is a quite objective and relatively simple way of assessing the situation of COVID-19 epidemic in countries. The complete picture must be given by a more complex analysis of other data such as the number of diagnoses per 100,000 inhabitants, distribution of these cases, and growth rate of the epidemics, among others. Nevertheless, any analysis based on diagnosed case is biased by diagnosis protocols and ratios in each country, as well as by the pool of asymptomatic cases. Any attempt to improve diagnosis percentage requires an economic, infrastructural and logistical effort that is not always possible. In addition, previous health system structure and management is a strong conditioning that limits possible actions to carry out in this direction.

Nevertheless, the **reported number of deaths, if uniformly and properly recorded, provides very relevant information as first general overview**. Even in countries where there is a bias on death reporting, the effort that should be made to improve these data collection is much lower than the necessary effort to increase data about cases. However, there are some peculiarities that require reflection. Currently, the total number of reported deaths is normally given together with the Case Fatality Rate (CFR). This is one of the parameters we provide every day in one of the tables in this report by the EU+EFTA+UK. As we proceed to discuss a simple glance without context can be a false friend.

A proper analysis depends very much on whether the number of reported deaths is as uniform in its criteria and as accurate as possible. All countries should have a special interest in knowing as much as possible about this information, as it can serve to give political advice and to share with the population the need for some of those decisions. Unfortunately, the analysis of the situation in European countries is not as solid as it could be since we do not have data on whether patients die in the hospital, at home or at nursing homes. It is also common not to have a distribution of CFR by age and sex in many countries. More importantly, **there is still not a distinction between deaths that have been diagnosed with laboratory tests and those that have been diagnosed by symptomatology, if included in reports**. Complete information on the death toll of the epidemics would allow us to give a full and better picture. Still, with the information at hand, we have developed a method to give a much better picture of the European situation that will be included in the analyses in the next days. We start here with a general overview.

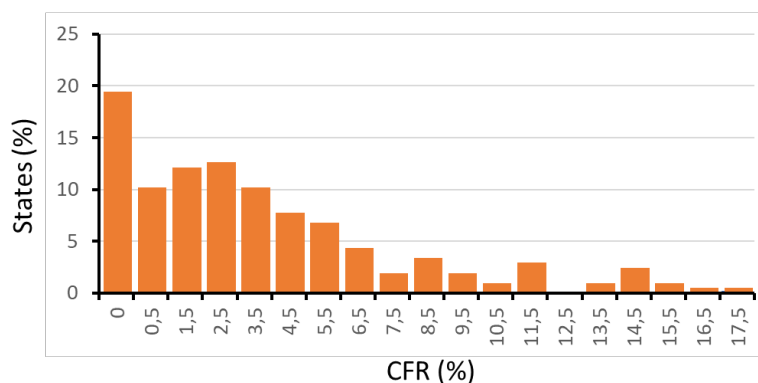
Despite the fact that the situation has improved for all EU+EFTA+UK countries, the epidemic is far from over if we look at the evolution of reported deaths. Mortality can be a useful guide to roughly estimate the actual extent of the epidemic in the number of infected; thus, it is also interesting to have the best quality data available. **To determine the extent of the epidemic in this case, we can compare lethality** (i.e., what percentage of infected people die as a result of the infection) **with CFR**. This gives a rough idea of what percentage of diagnosis is, which will be the core of forthcoming reports.

The best way to understand how this comparison can give you a back of the envelope insight is using an example. France and Germany, with 111,821 and 139,897 cases respectively, have similar numbers of reported cases (data from yesterday). These two countries have very different reported deaths, with 19,323 in France and 4,294 in Germany. The main reason is that the level of diagnosis depends largely on the number of diagnostic tests performed per capita. **If we consider that both countries have probably similar lethality, we can associate the difference in CFR with a difference in the number of tests and diagnosis**. With this simple calculation, one can estimate that the **spread of the epidemic in France is around 5 times more important**. This is, if France were to perform as many diagnostic tests per capita as in Germany, France would probably have more than half a million cases. In our daily reports, we roughly estimate total attack rate of countries (including asymptomatic and mild cases) by assuming a 1 % lethality and comparing it with reported CFR, as well as a delay of 18 days before onset of the symptoms and death.

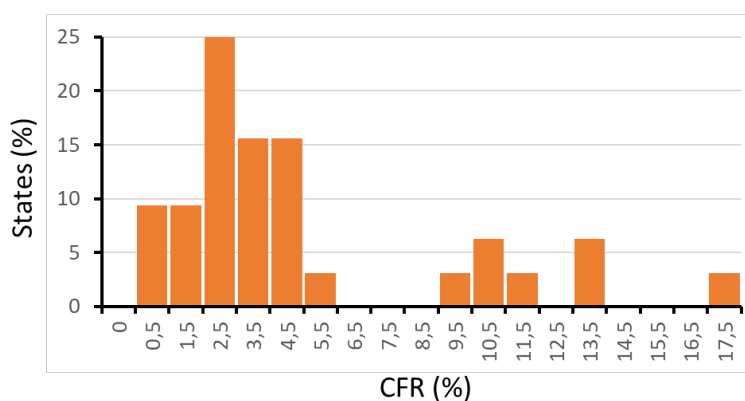
We must point out immediately that it is not that simple and that a more detailed analysis is required, since there are several **factors that affect CFR and lethality**. Here is a short list:

1. The number of diagnostic tests per inhabitant.
2. The actual number of deaths reported. In many countries, the cause of many deaths has not been identified and therefore not reported. This may be especially important in countries where nursing homes have had outbreaks of disease, which have been fatal but have not been counted because they have not been diagnosed.
3. Lethality depends on the age structure of the population; in countries with a very young population, overall mortality can be expected to be lower.
4. Mortality increases throughout the course of the epidemic. From the moment a person is diagnosed to his death, about 18 days have elapsed. Therefore, CFR starts at low values at the initial stages of the epidemic and progressively increases until it can reach a more or less stationary value, if other factors do not change.

We can take now a look at the world and distribute the different countries according to their CFR. This figure gives the **percentage of states that have the CFR in indicated intervals** (data from yesterday). X-axis indicate the mean point of the considered interval (e.g., the bar above 2.5 indicates the percentage of countries with a current CFR between 2 % and 3 %).



Using ECDC data, we can observe that at least one case has been diagnosed in all countries, but in 20% of the countries no death has yet been reported. Not considering these countries with no reported death, the **CFR mode stands at 2.5%**, which probably just tells us that in many states the spread of the epidemic is at an early stage. To date (yesterday for the reader), we find that in the world there have been 159,511 deaths for 2,281,714 cases diagnosed, which corresponds to a CFR of 7%. The **highest CFR corresponds to France with a CFR of 17.3%**. Focusing in Europe, we have this CFR distribution among countries:



After France, we find a CFR>10% in the United Kingdom (13.5%), Italy (13.2%), Netherlands (11.4%), Sweden (10.9%) and Spain (10.4%). We find the **mode again at 2.5 %**.

Finally, the following table shows the CFR for countries with more than 10,000 cases reported:

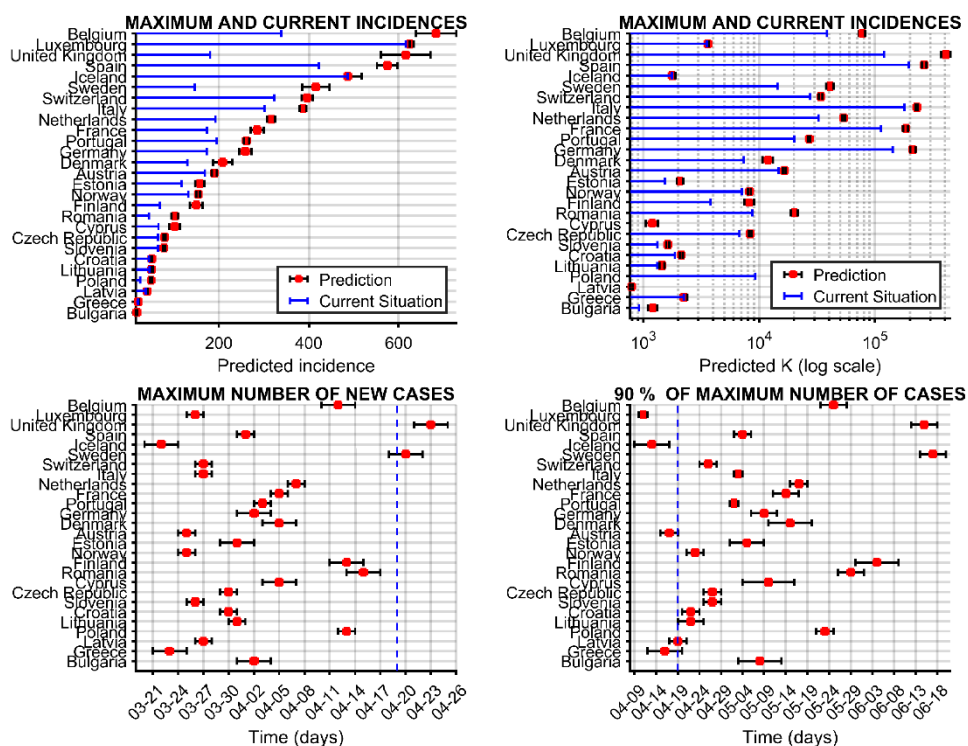
	Total confirmed cases	Total deaths	CFR (%)
USA	735,086	38,910	5.3
Spain	191,726	20,043	10.5
Italy	175,925	23,227	13.2
Germany	139,897	4,294	3.1
United Kingdom	114,217	15,464	13.5
France	111,821	19,323	17.3
China	83,803	4,636	5.5
Turkey	82,329	1,890	2.3
Iran	80,868	5,031	6.2
Belgium	37,183	5,453	14.7
Russia	36,793	313	0.9
Brazil	36,599	2,347	6.4
Canada	33,341	1,467	4.4
Netherlands	31,589	3,601	11.4
Switzerland	27,322	1,110	4.1
Portugal	19,685	687	3.5
India	15,712	507	3.2
Ireland	14,758	571	3.9
Austria	14,662	443	3.0
Peru	14,420	348	2.4
Sweden	13,822	1,511	10.9
Israel	13,265	164	1.2
South Korea	10,661	234	2.2
Japan	10,361	161	1.6

CFR is expected to be larger than lethality since it is not possible to detect people without symptoms in the first stages of the epidemic until population-wide studies are carried out. Initial reports where aleatory detection protocols have been carried out in Germany and Iceland point to a lethality around 0.5%. However, these analyses have not been done to a representative population of those infected and not in an advance stage of the epidemic. They might be demographically correct but are, so far, purely local. A reasonable middle point between the mode of CFR and preliminary analysis of random samples suggest a real lethality of around 1 %. Despite its uncertainty, anywhere between 0.3% and 3%, using 1% as lethality can provide deep insights of the state of the epidemics.

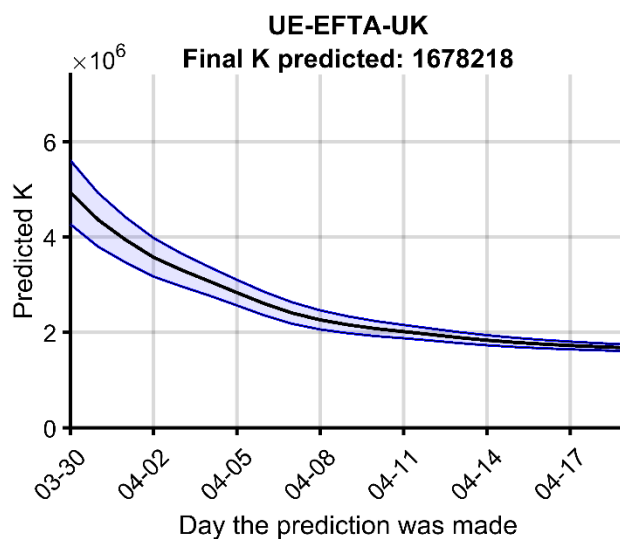
Long-term predictions

Long-term predictions, evaluated with the **whole historical series** and without weighting last 3 points. Up-left: Predictions of maximum incidences per country (total final expected attack rate per 10^5 inh.). Up-right: Predictions of maximum absolute number of cases per country (K, in log scale). Blue lines indicate current situation. Bottom-left: Time in which peak in new cases was achieved / will be achieved. Bottom-right: Time at which 90 % of K was achieved / will be achieved. Blue dotted line indicates current date. See details in Report from 11th April 2020.

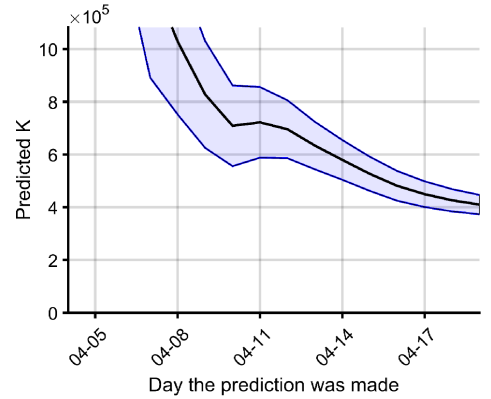
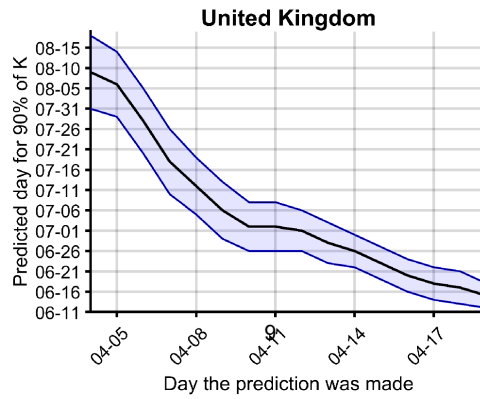
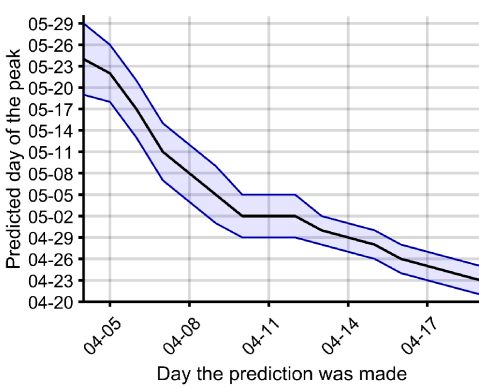
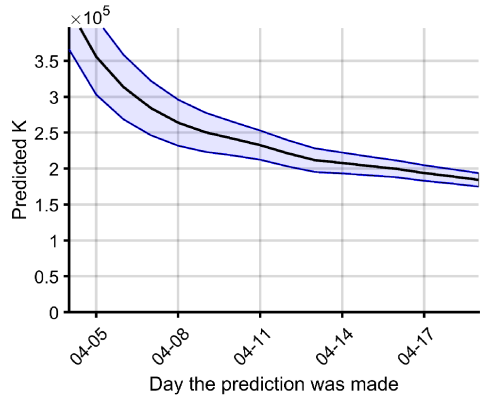
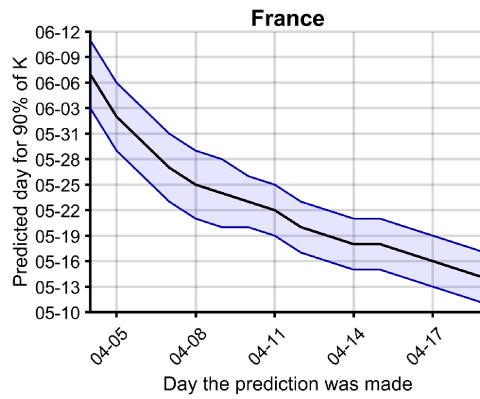
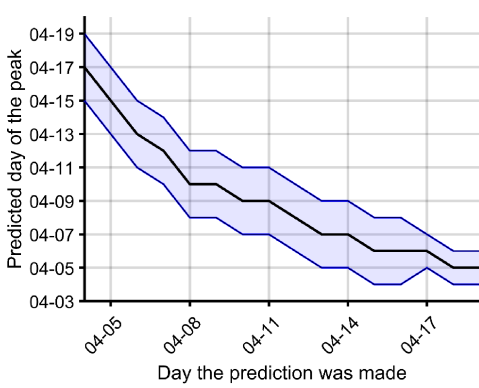
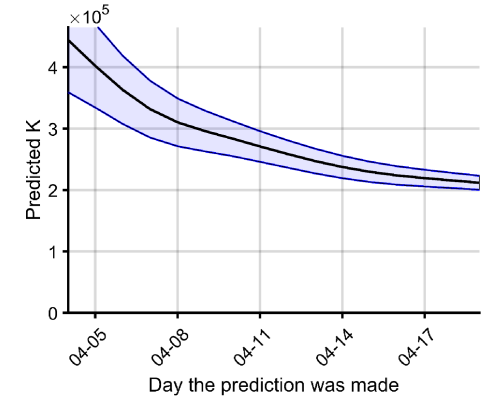
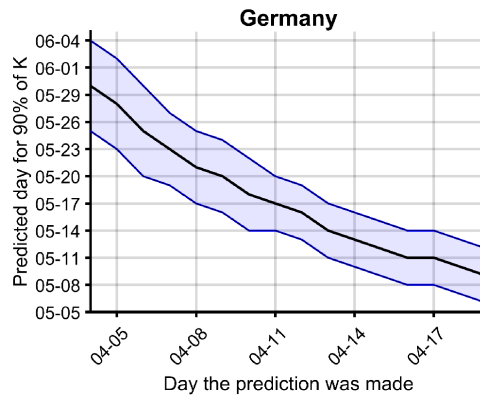
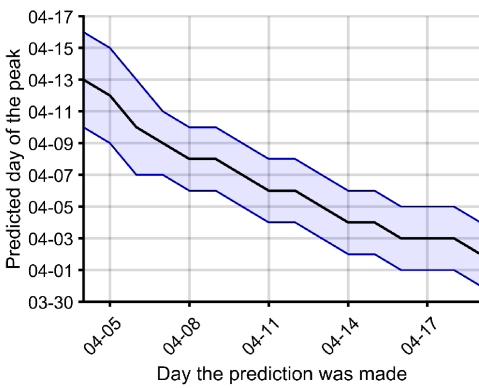
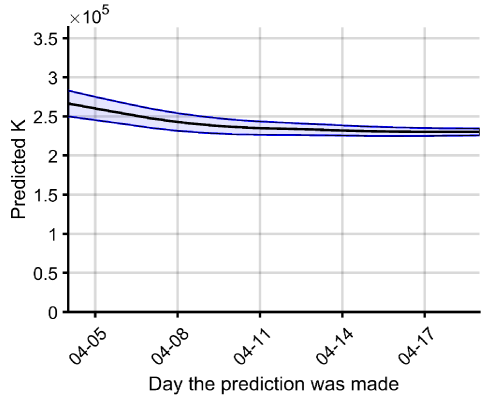
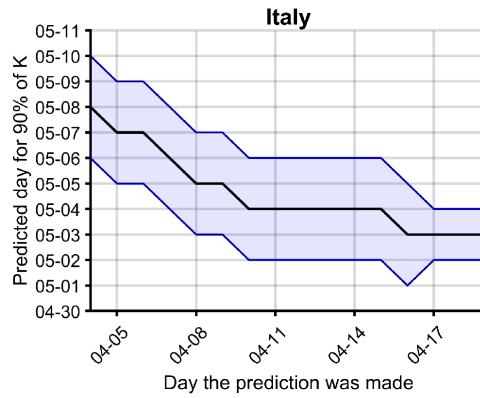
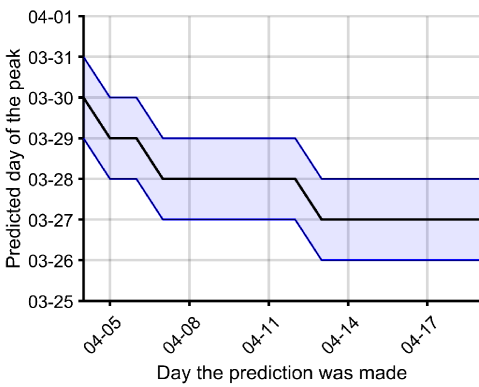
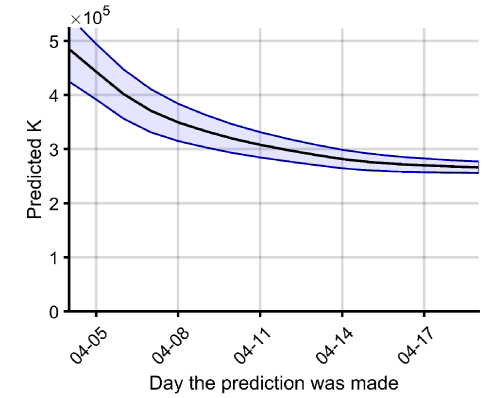
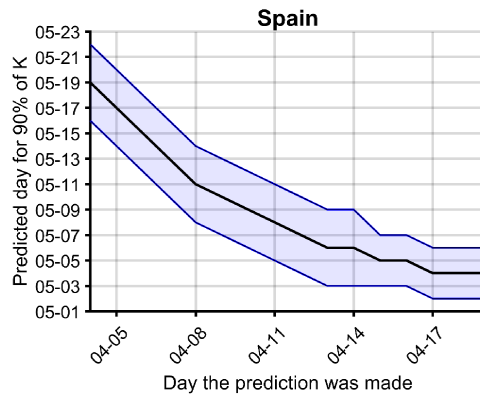
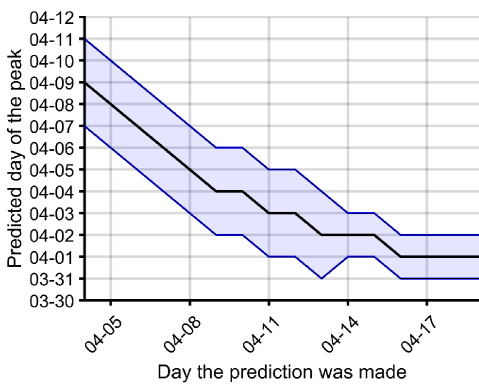
UE-EFTA-UK countries



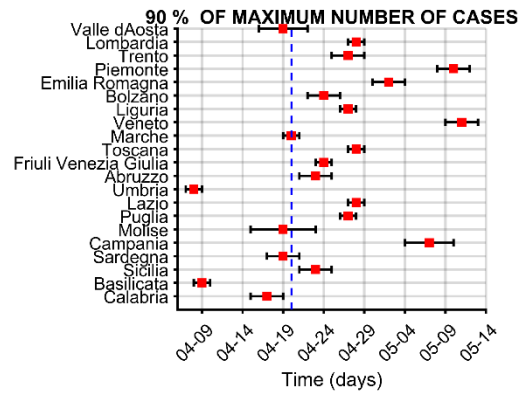
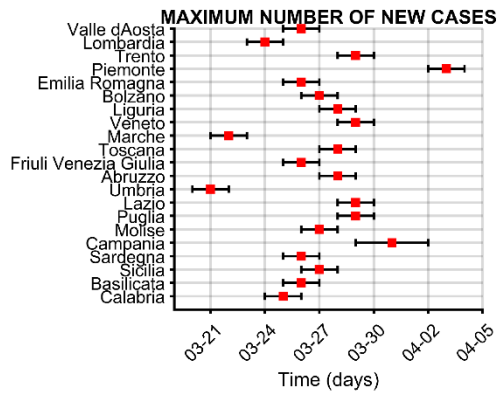
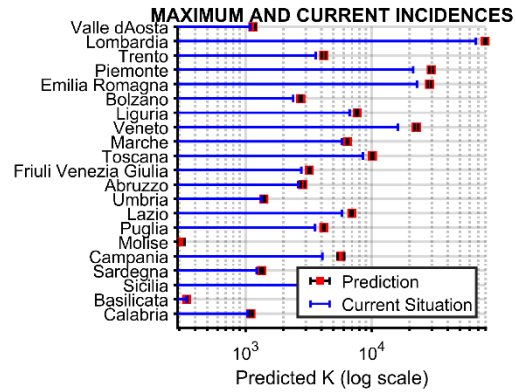
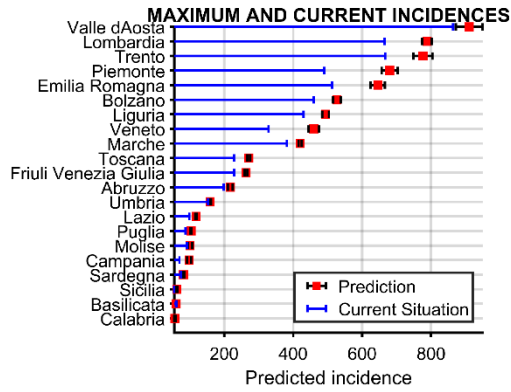
Final expected K for UE+EFTA+UK. Evolution of predicted K with time, where convergence to best estimate is seen. Last prediction is numerically shown in title.



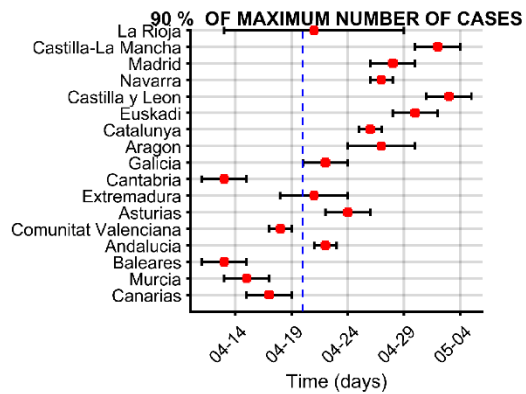
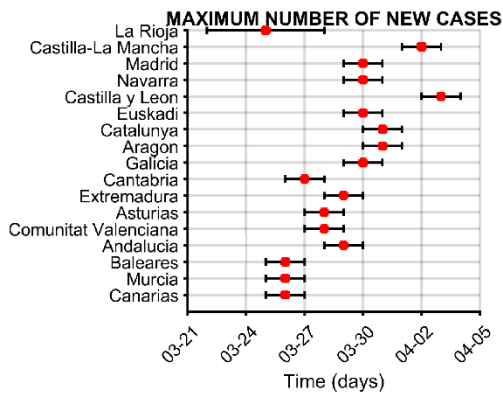
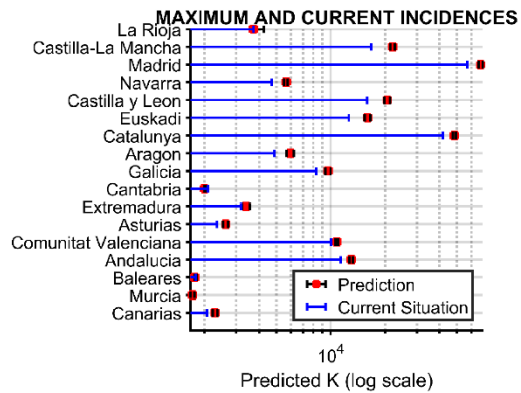
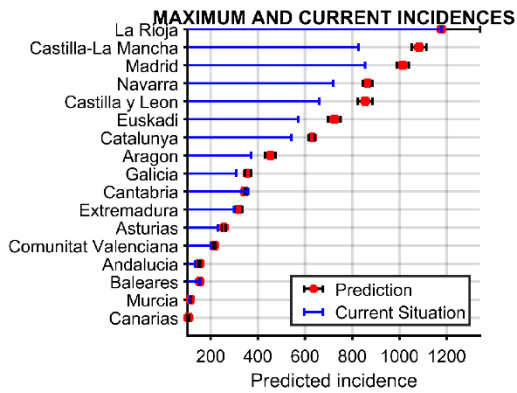
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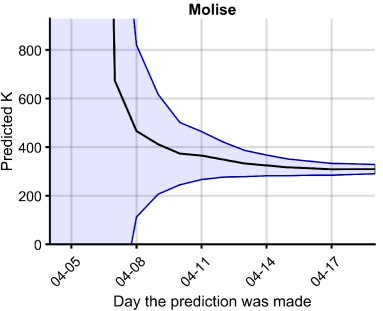
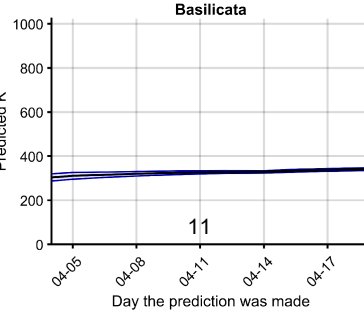
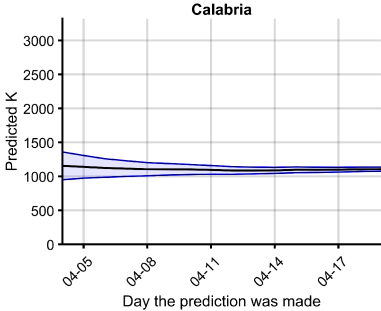
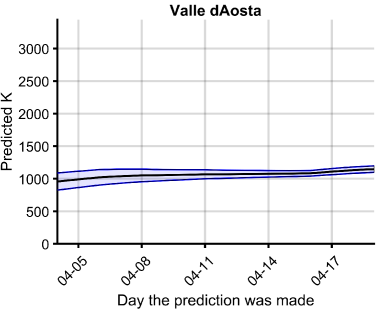
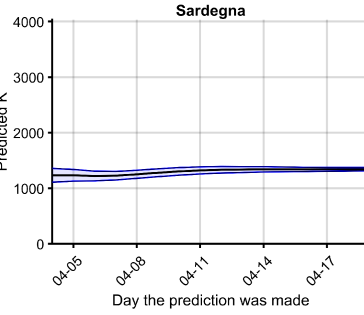
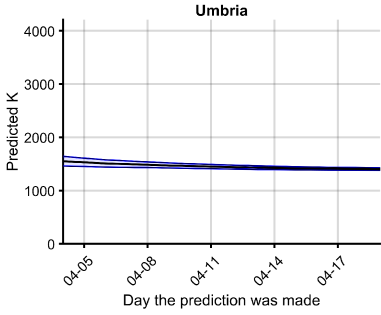
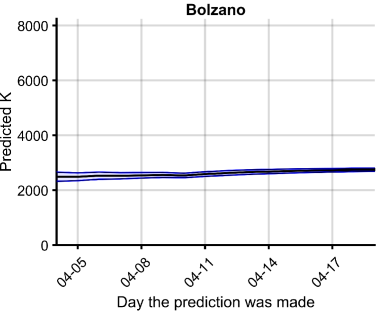
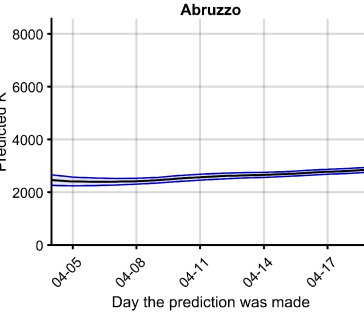
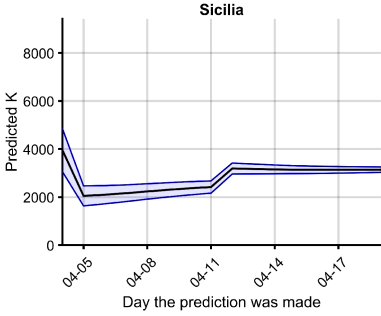
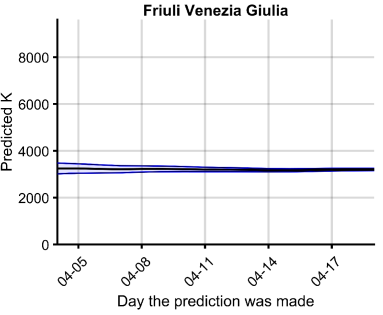
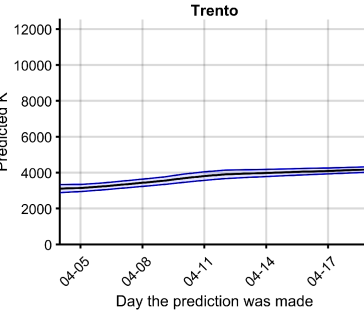
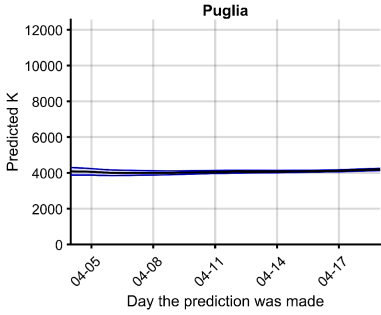
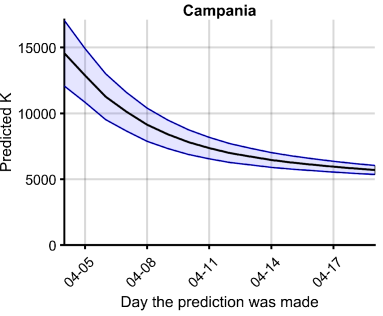
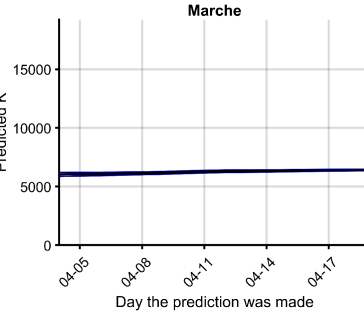
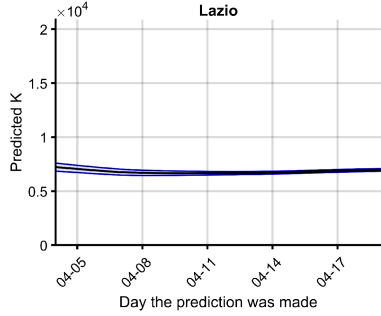
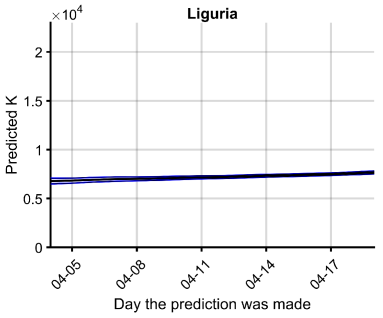
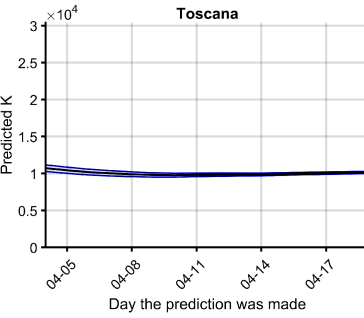
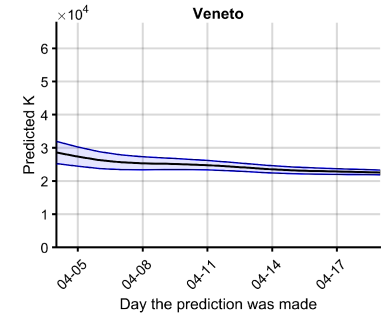
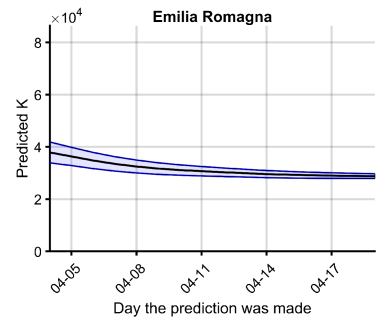
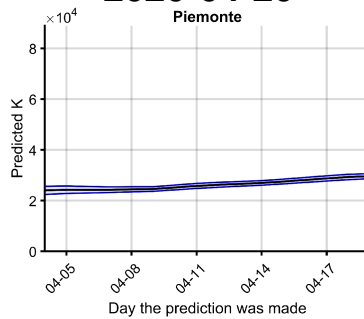
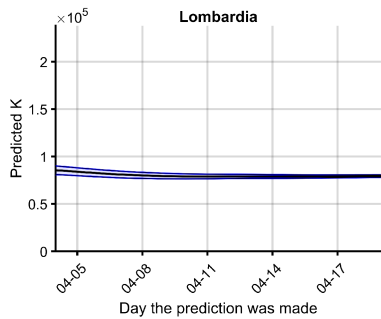
Italian regions



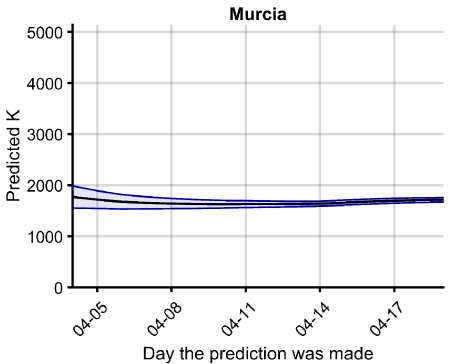
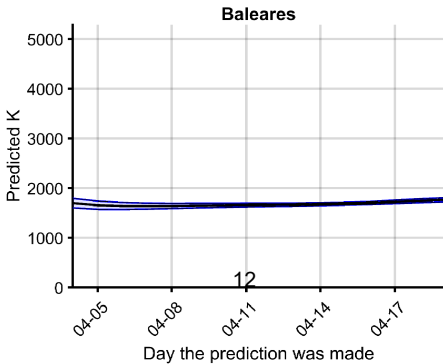
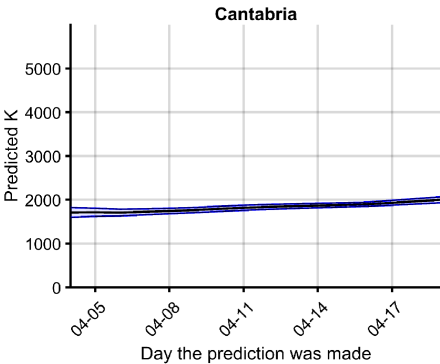
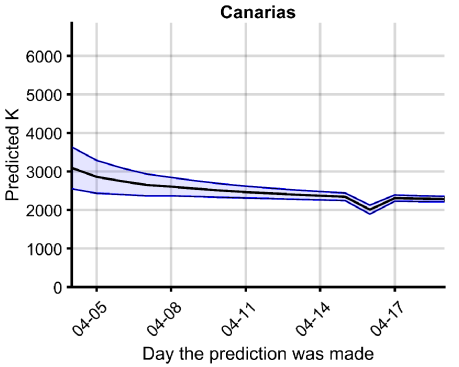
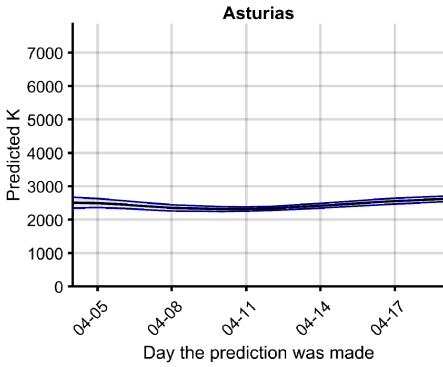
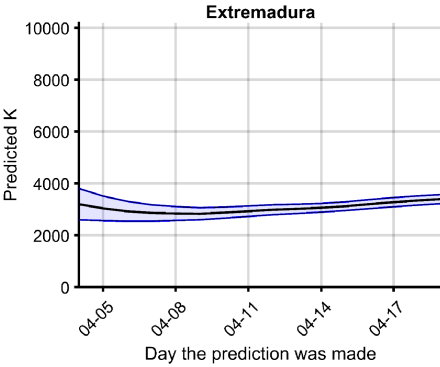
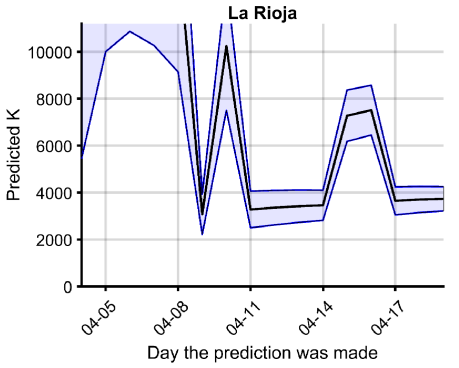
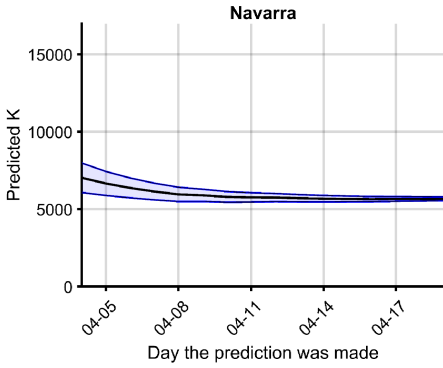
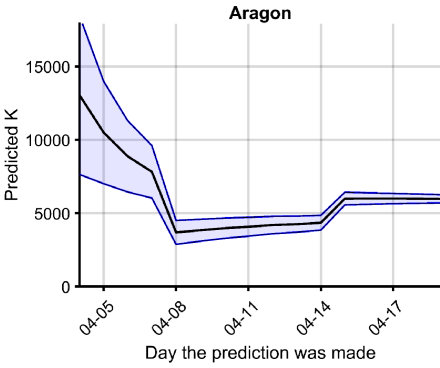
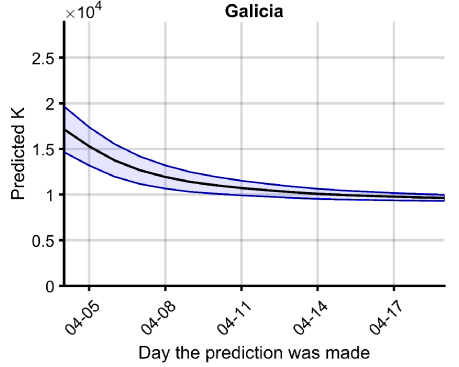
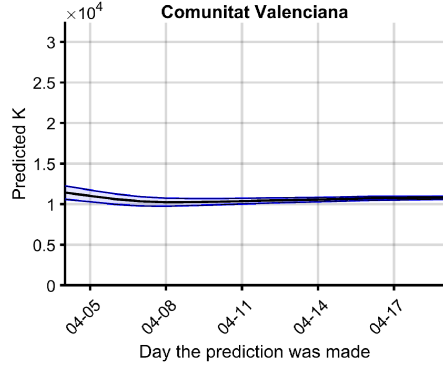
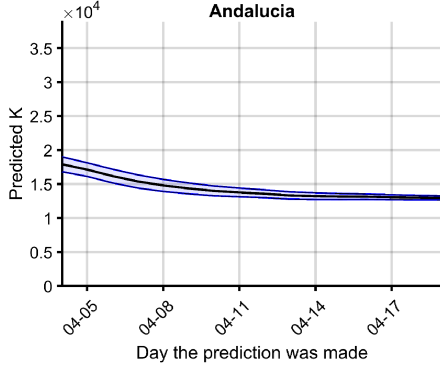
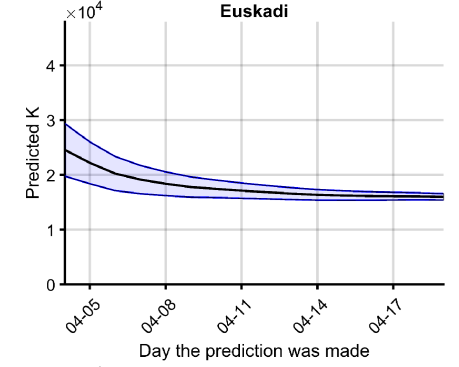
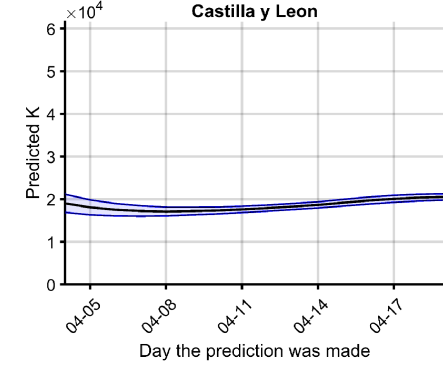
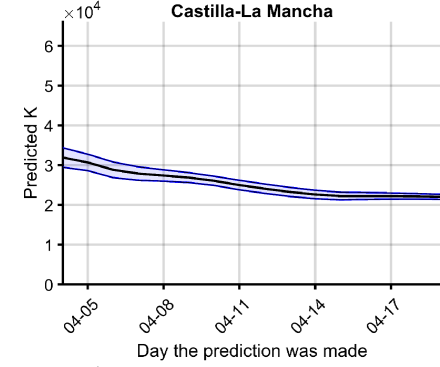
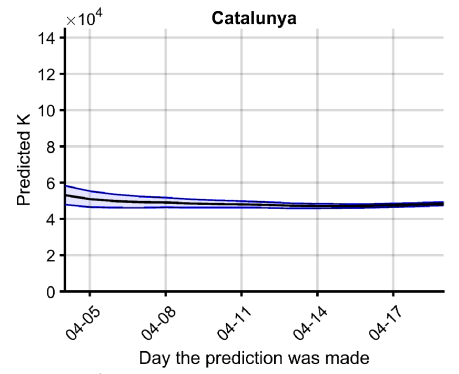
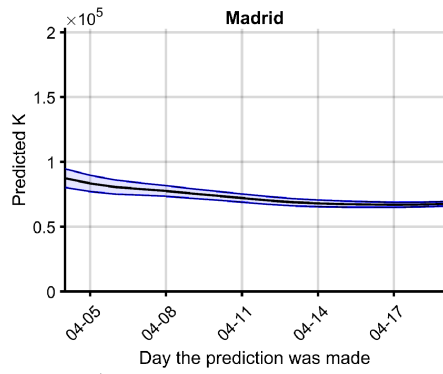
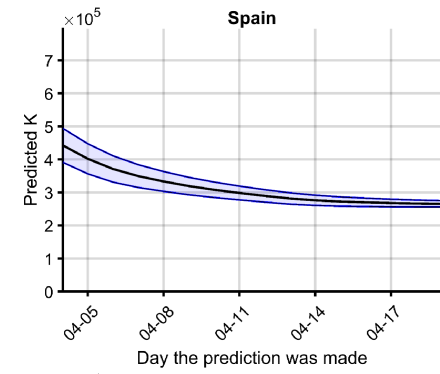
Spanish regions



2020-04-20



2020-04-20



Situation and tendencies in Italian and Spanish regions

Italy. Data from 19/04/2020

Country	Reported data						Indexes		
	Cumulative cases	Attack rate / 10 ⁵ inh.	Cumulative deaths	Mortality / 10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate / 10 ⁵ inh.	Mean p ⁽¹⁾	EPG ⁽²⁾	EPG2 ⁽²⁾
Lombardia	66,971	666.9	12,376	123.2	15,437	153.7	0.84	128.8	107.8
Emilia Romagna	22,867	512.8	3,079	69.0	5,311	119.1	0.98	117.2	115.3
Piemonte	21,349	490.1	2,409	55.3	8,425	193.4	1.07	206.1	219.7
Veneto	16,127	328.7	1,112	22.7	4,539	92.5	1.36	126.0	171.7
Toscana	8,507	228.1	667	17.9	2,506	67.2	0.85	56.8	48.0
Liguria	6,669	430.1	957	61.7	2,120	136.7	1.04	142.3	148.0
Marche	5,826	382.0	822	53.9	1,212	79.5	0.80	63.4	50.6
Lazio	5,815	98.9	349	5.9	1,784	30.3	0.95	28.8	27.4
Campania	4,074	70.2	309	5.3	1,016	17.5	0.65	11.5	7.5
Trento	3,590	334.8	366	34.1	1,242	115.8	1.12	129.5	144.8
Puglia	3,567	88.5	326	8.1	1,123	27.9	1.13	31.4	35.3
Friuli Venezia Giulia	2,775	228.4	239	19.7	672	55.3	1.10	61.0	67.2
Sicilia	2,759	55.2	203	4.1	713	14.3	1.00	14.3	14.4
Abruzzo	2,612	199.1	263	20.1	891	67.9	1.32	89.5	117.9
Bolzano	2,394	2,228.3	249	231.8	672	625.5	0.60	374.5	224.2
Umbria	1,349	152.9	58	6.6	96	10.9	2.27	24.7	56.0
Sardegna	1,228	74.9	86	5.2	306	18.7	0.90	16.8	15.1
Valle d'Aosta	1,088	866.2	127	101.1	283	225.3	2.52	568.0	1,432.1
Calabria	1,038	53.3	75	3.9	221	11.4	1.03	11.7	12.1
Basilicata	342	60.8	24	4.3	55	9.8	1.19	11.7	13.9
Molise	281	91.9	18	5.9	57	18.7	1.29	24.1	31.2

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500.0	500.0
Best	Best	Best	Best	Best	Best	Best	0.0	0.0	0.0

Spain. Data from 17/04/2020

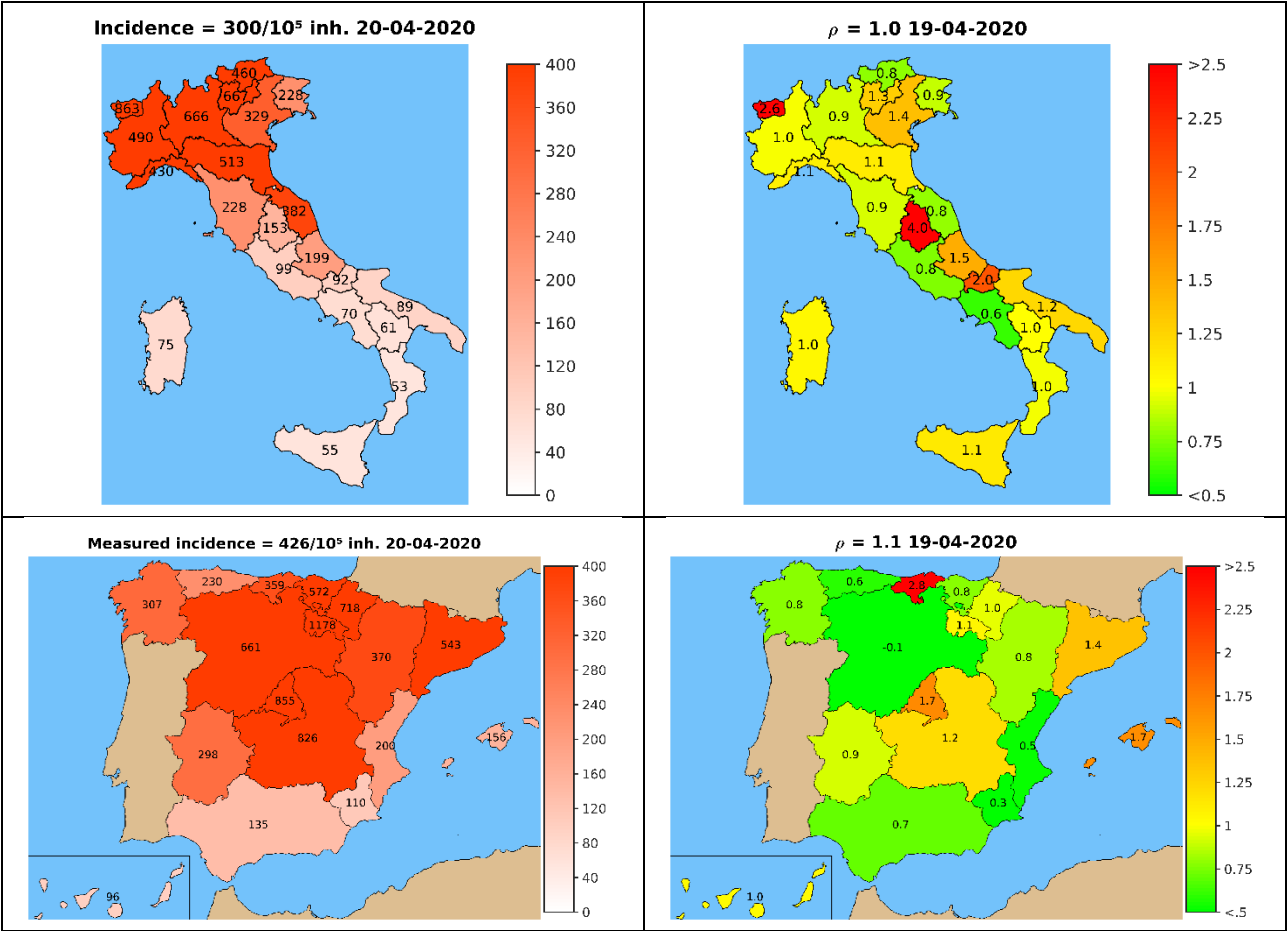
Autonomous regions	Reported data						Indexes		
	Cumulative cases	Attack rate / 10 ⁵ inh.	Cumulated deaths	Mortality rate / 10 ⁵ inh.	Active cases (last 14 days)	14-day attack rate / 10 ⁵ inh.	Mean p ⁽¹⁾	EPG ⁽²⁾	EPG2 ⁽²⁾
Madrid	56,963	857.8	7,351	110.7	18,240	274.7	1.68	461.8	776.4
Catalunya	41,676	550.9	4,009	53.0	14,852	196.3	1.34	262.2	350.3
Castilla-La Mancha	16,796	825.2	2,021	99.3	7,680	377.3	1.21	454.8	548.2
Castilla y Leon	15,857	658.5	1,493	62.0	5,255	218.2	0.69	151.3	104.9
Euskadi	12,628	579.8	1,081	49.6	3,818	175.3	0.94	165.0	155.3
Andalucía	11,323	134.4	1,013	12.0	2,742	32.5	0.66	21.6	14.4
Comunitat Valenciana	10,018	201.4	1,079	21.7	2,684	54.0	0.51	27.5	14.0
Galicia	8,299	307.3	352	13.0	2,148	79.5	0.73	58.2	42.6
Aragon	4,886	369.9	637	48.2	1,539	116.5	0.99	115.6	114.7
Navarra	4,697	722.7	385	59.2	1,466	225.6	0.89	201.0	179.2
La Rioja	3,734	1,190.8	285	90.9	1,015	323.7	0.92	297.6	273.6
Extremadura	3,186	299.1	389	36.5	1,118	104.9	1.06	111.4	118.2
Asturias	2,348	229.7	200	19.6	702	68.7	0.8	51.7	38.9
Cantabria	2,083	358.1	158	27.2	600	103.1	2.29	236.6	542.6
Canarias	2,067	93.6	119	5.4	418	18.9	0.85	16.1	13.6
Baleares	1,788	150.5	157	13.2	468	39.4	2.03	79.9	161.9
Murcia	1,646	110.6	117	7.9	387	26.0	0.80	20.7	16.5
Ceuta	111	130.8	4	4.7	28	33.0	ND	ND	ND
Melilla	104	122.8	2	2.4	18	21.2	ND	ND	ND

Scale									
Worst	Worst	Worst	Worst	Worst	Worst	Worst	2.0	500.0	500.0
Best	Best	Best	Best	Best	Best	Best	0.0	0.0	0.0

- (1) Disclaimer: parameter p is very sensitive and experiments daily variations. Mean p is averaged per 3 consecutive days, but it can still vary the following days. ⁽²⁾ EPG stands for Effective Growth Potential. It is obtained by multiplying attack rate per 10⁵ inhabitants of last 10 days (i.e. density of cases) by p (a value related with effective reproduction number and that, therefore, determines the dynamics for subsequent days). EPG2 is a similar index but attack rate of last 10 days is multiplied by p².

Maps of Italian and Spanish regions

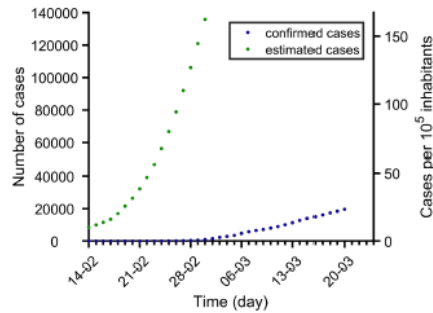
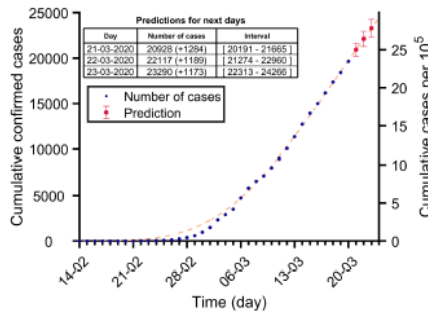
Cumulated incidence and spreading rate (ρ) in Europe, Italian regions and Spanish autonomous communities.



Legend: Countries' reports details

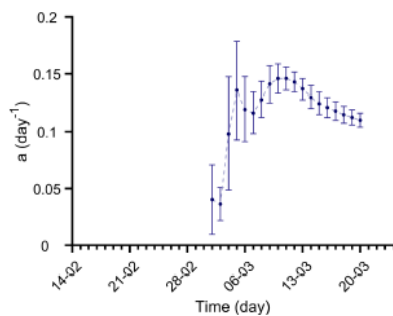
Iran 20-03-2020. Population: 83.7M. Current cumulated incidence: $23/10^5$

Confirmed cases:
data (blue),
model fitted
(dashed line),
predictions (red
points and table)

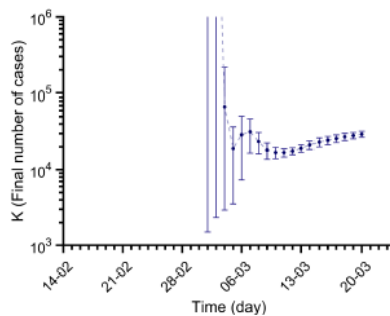


Estimated
cases using
death rate (see
Methods)

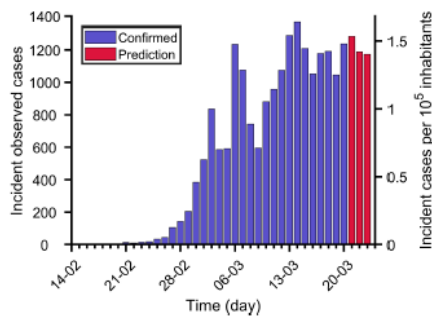
Fitted α value
using points
prior to each
date



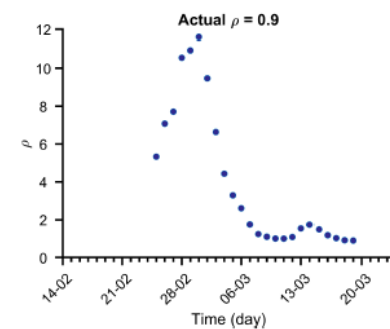
Fitted K value
using points
prior to each
date



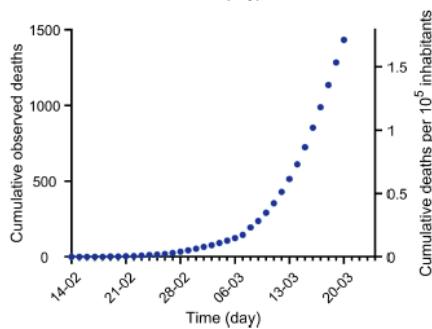
Reported
and
predicted
new cases



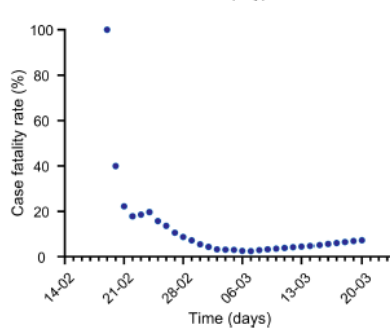
Evolution of ρ , a
parameter related
with Reproduction
number (see
Methods)



Reported
deaths

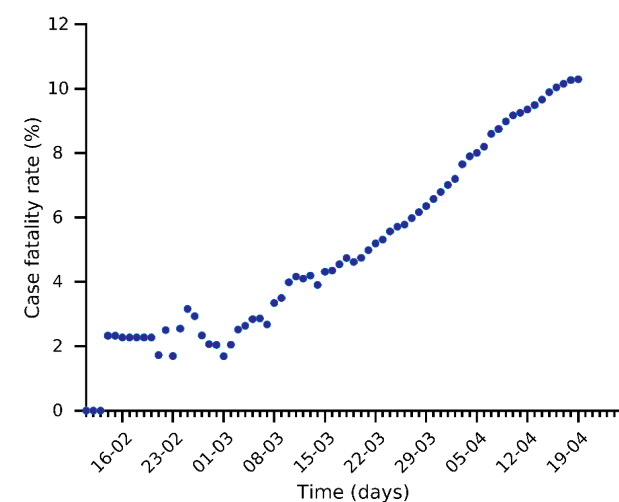
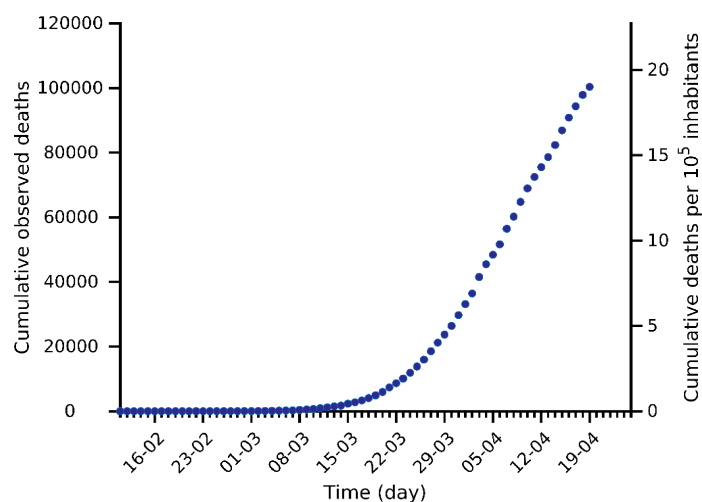
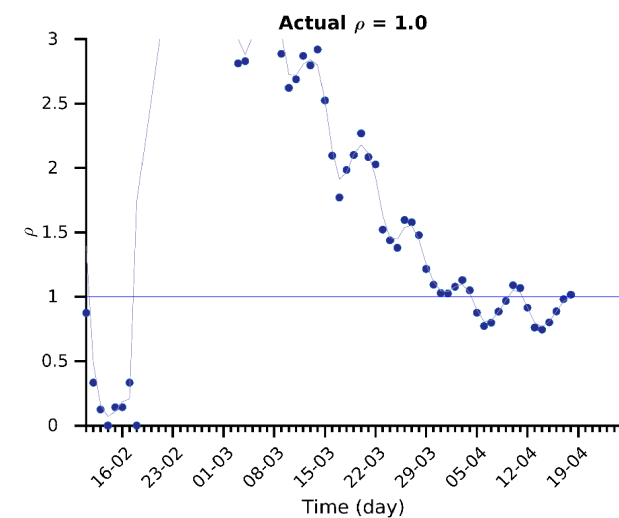
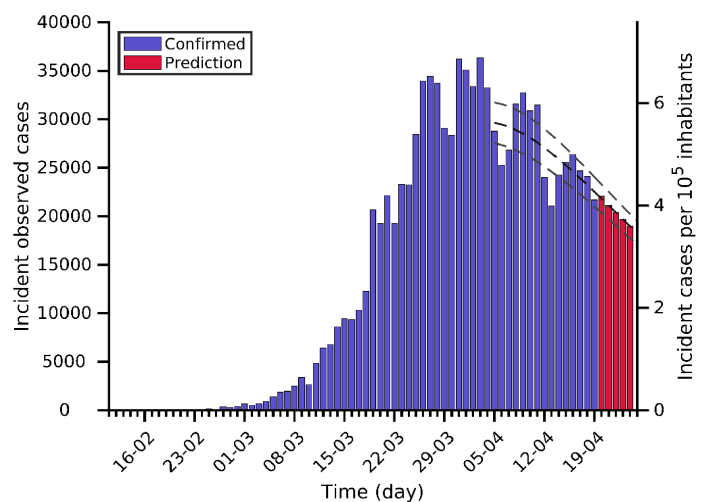
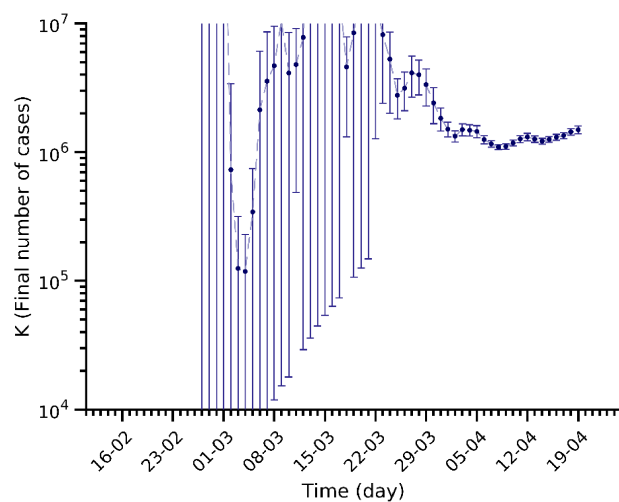
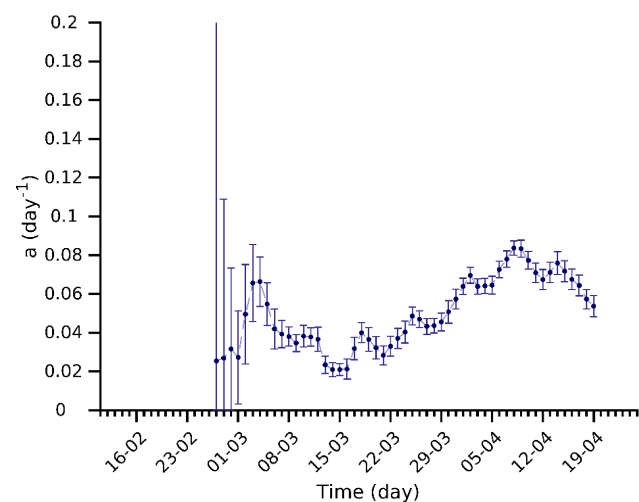
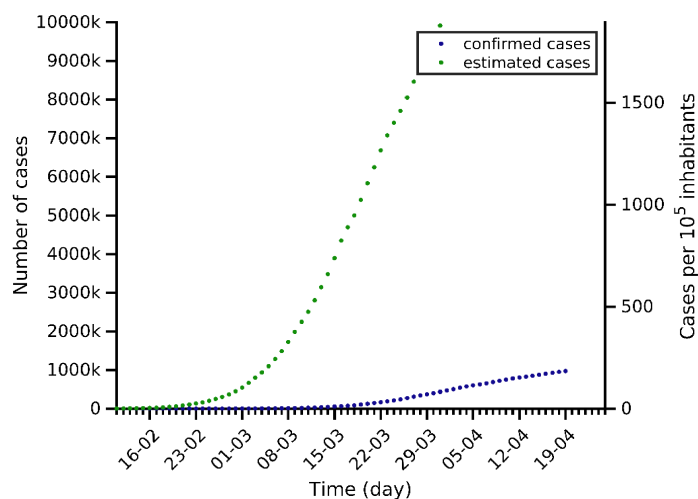
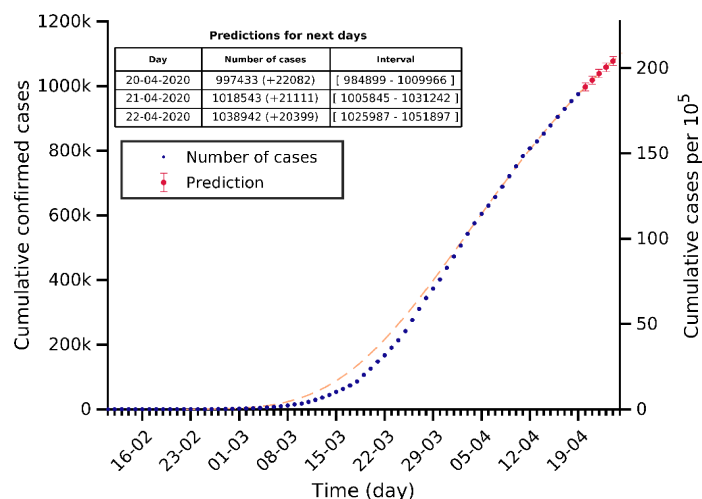


Deaths /
cumulated
reported cases

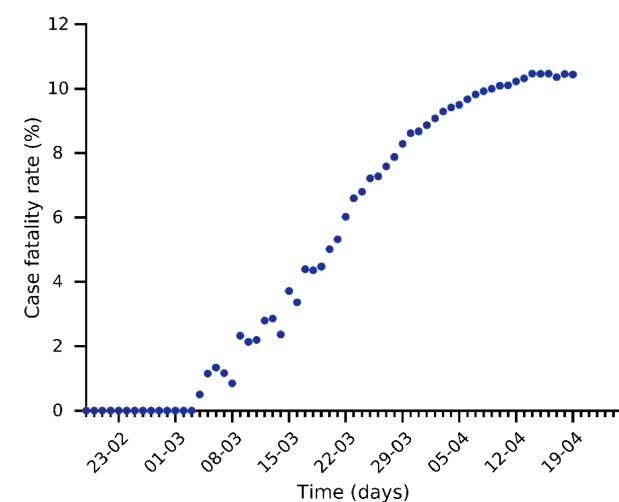
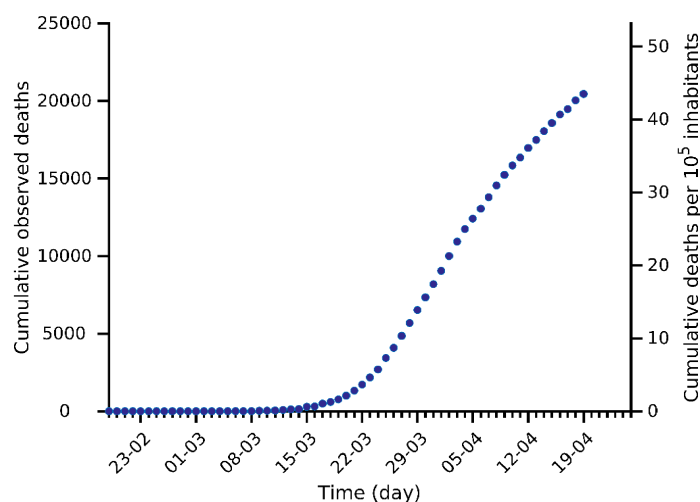
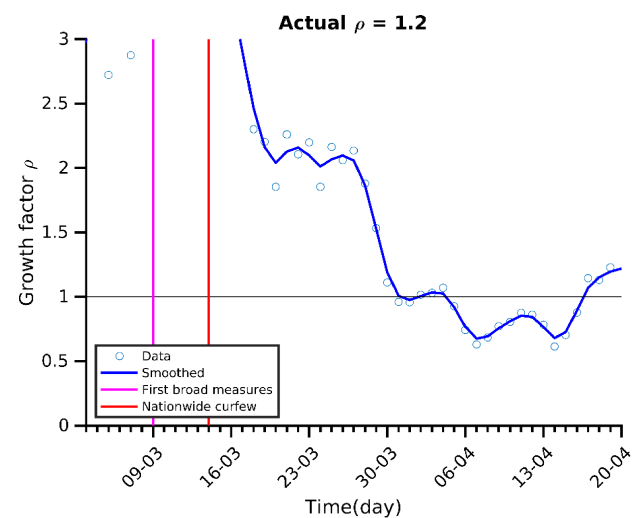
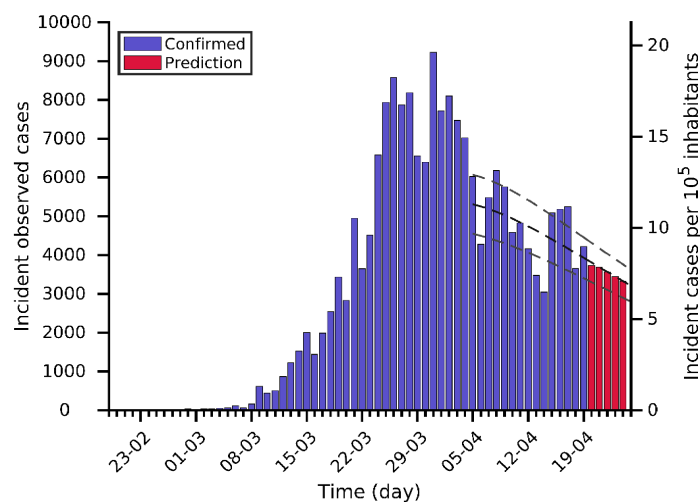
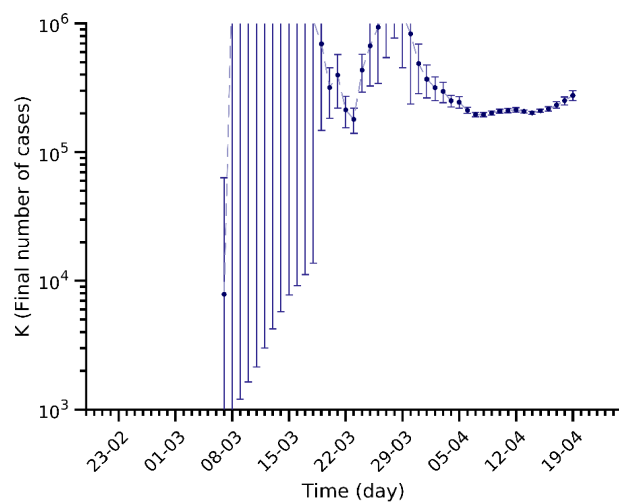
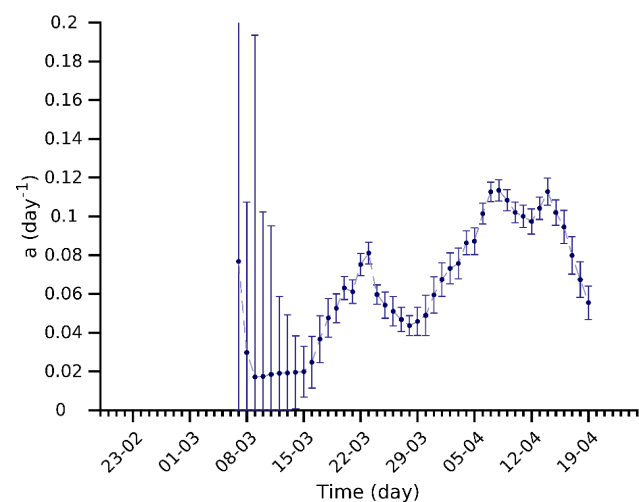
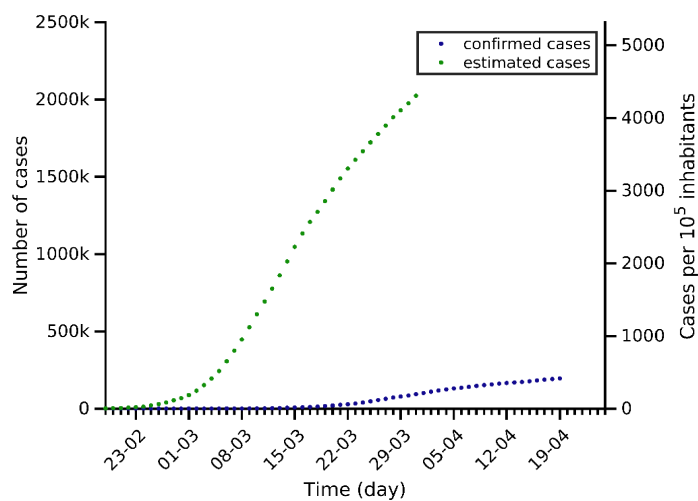
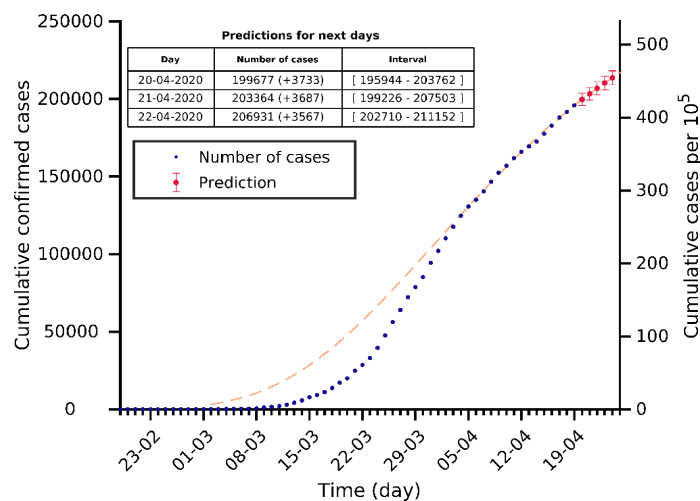


(1) Analysis and prediction of COVID-19 for EU+EFTA+UK

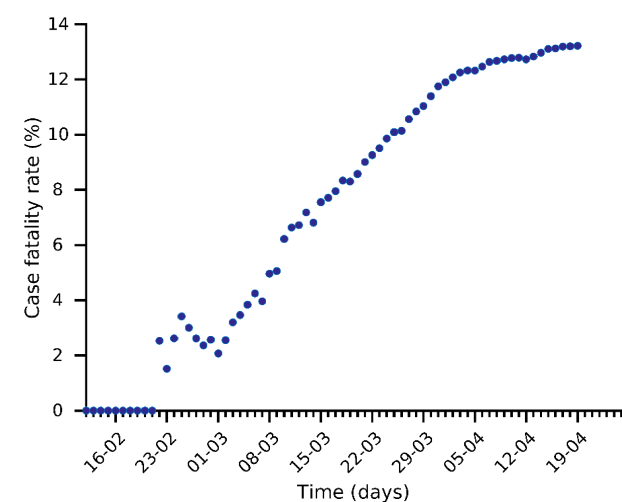
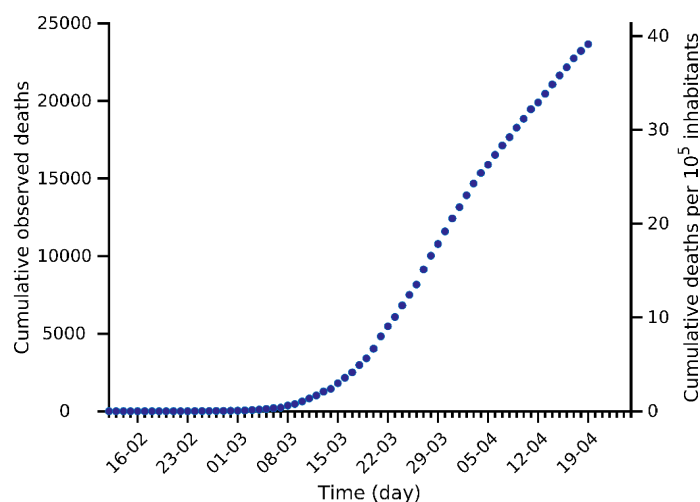
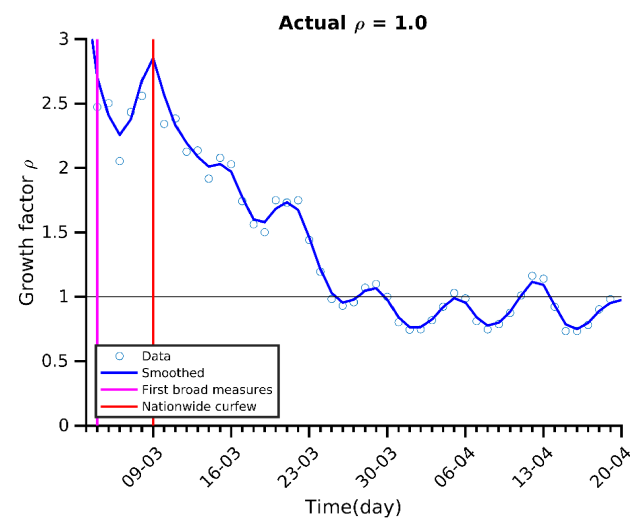
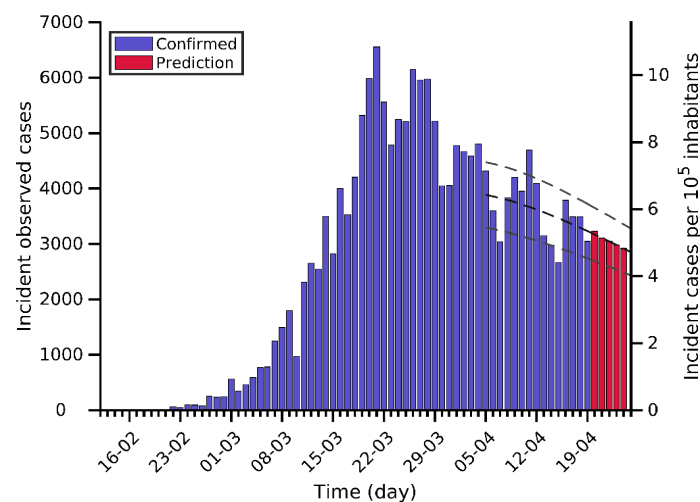
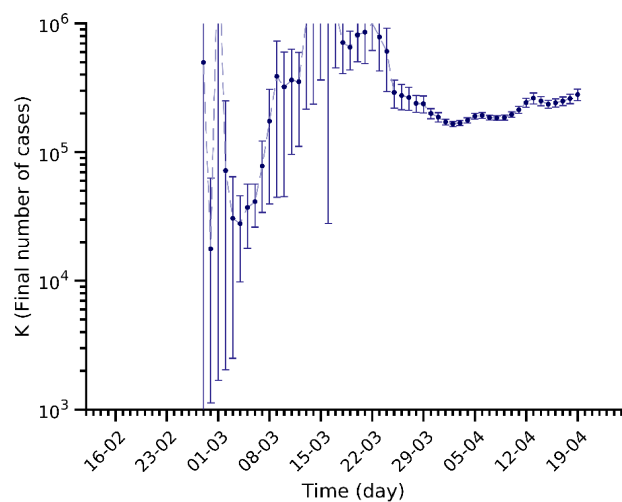
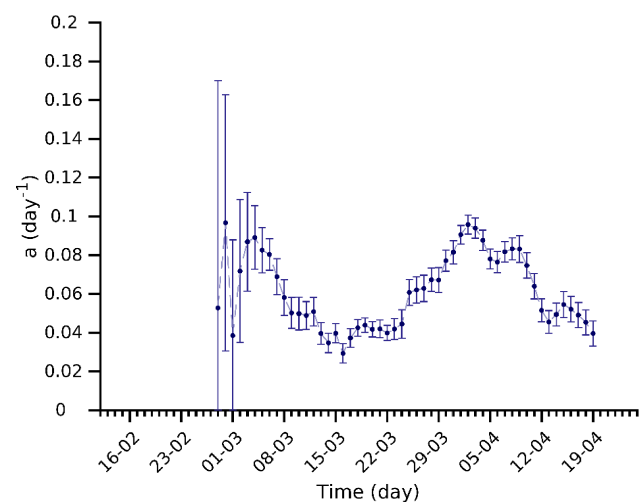
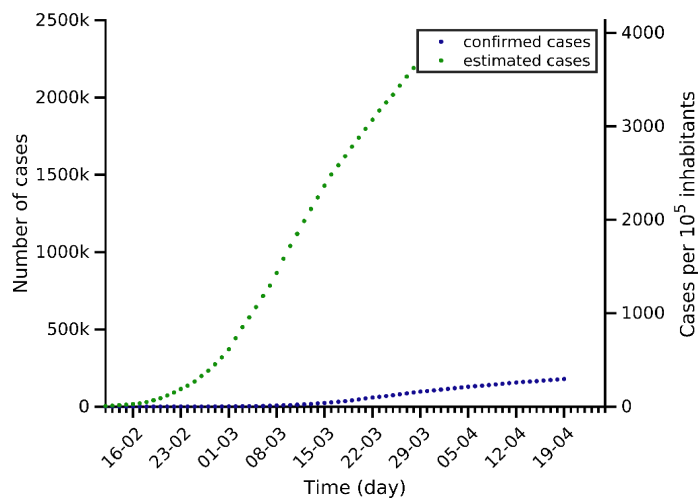
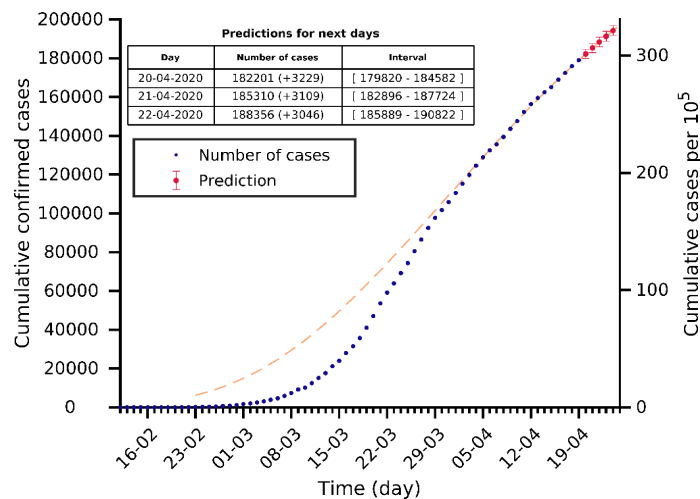
Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>
<https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale> (Italy)



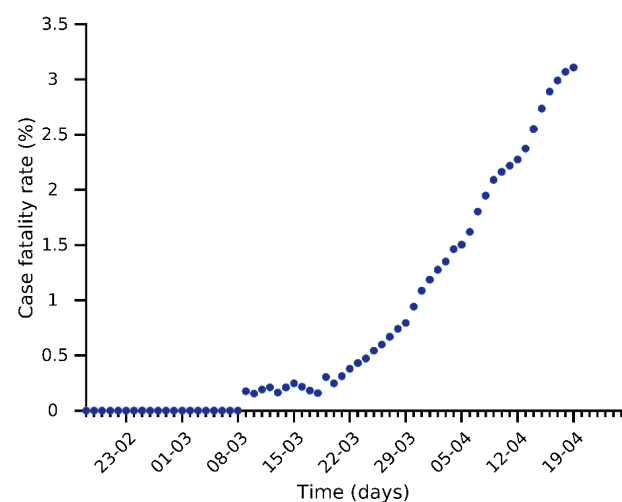
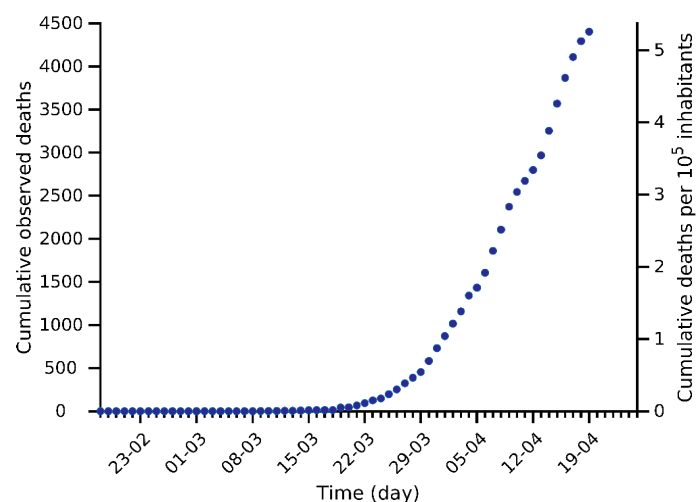
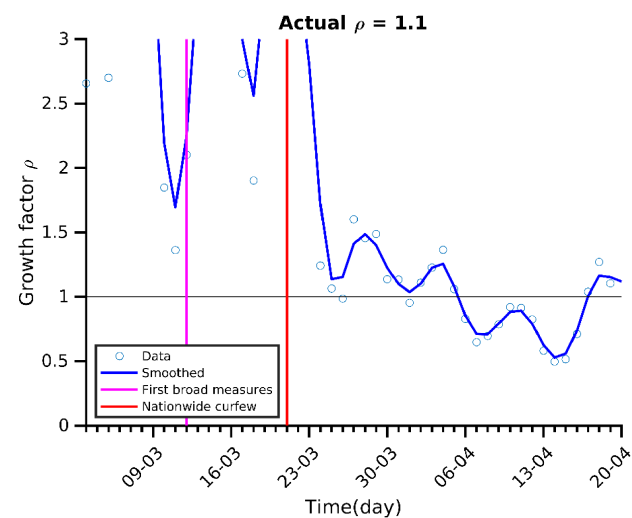
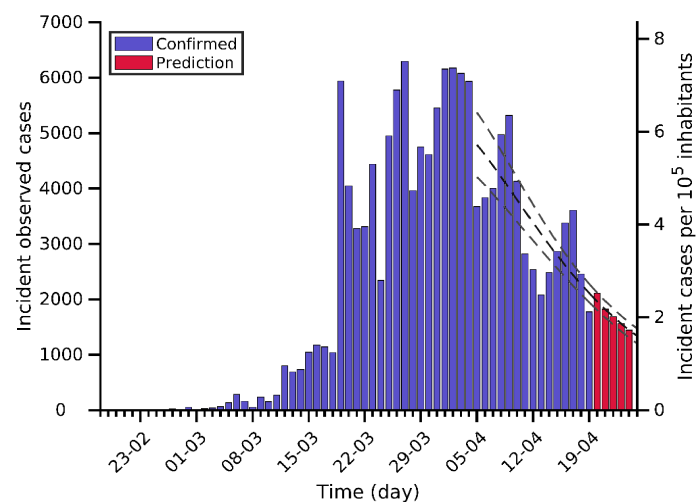
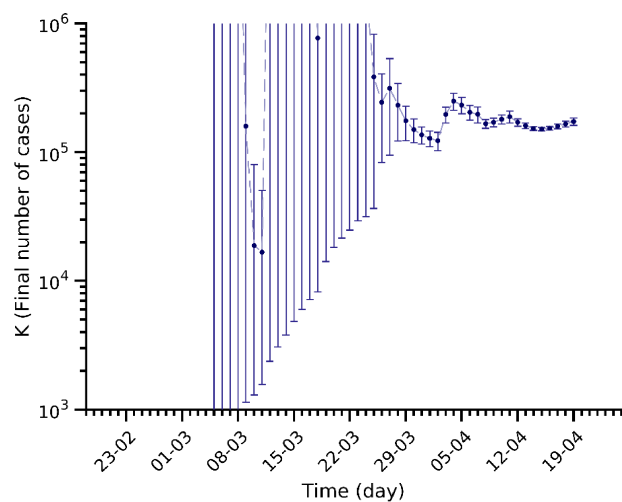
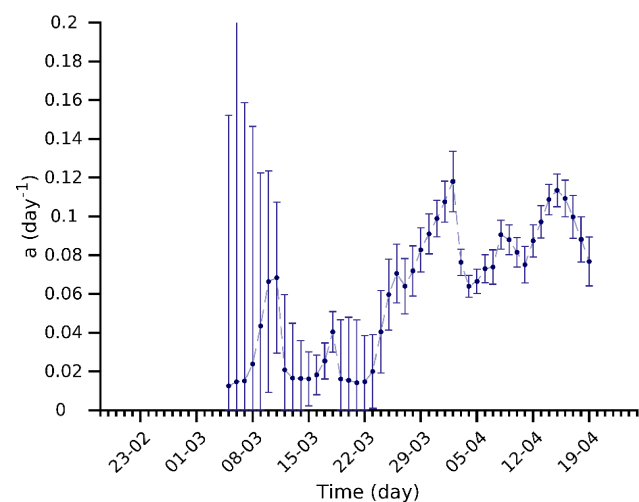
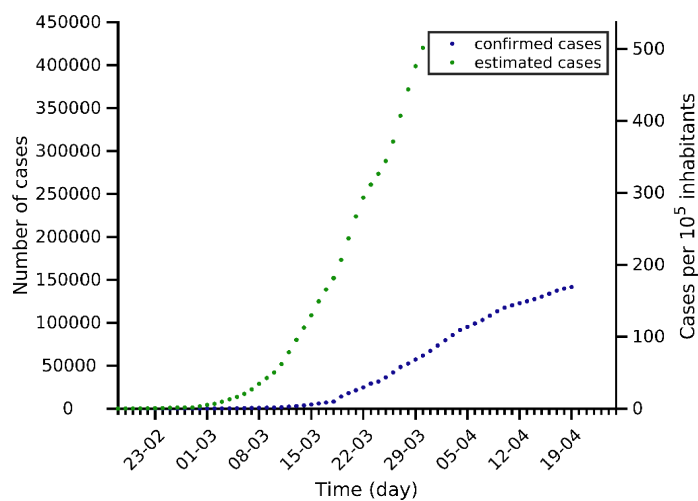
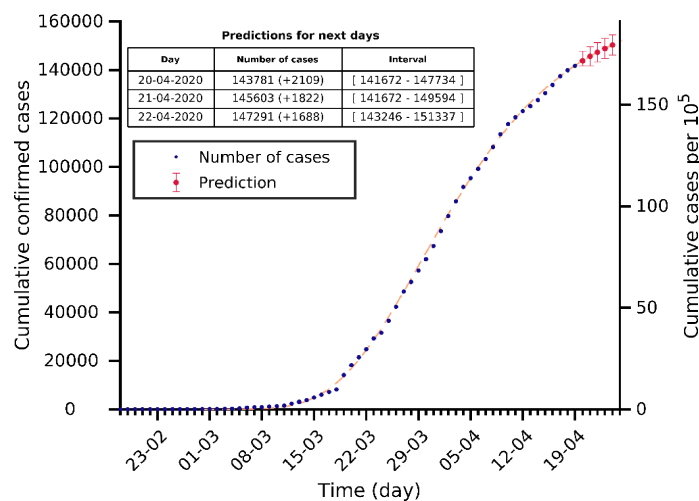
Spain 19-04-2020. Population: 47.0M. Current cumulated incidence: 417/10⁵



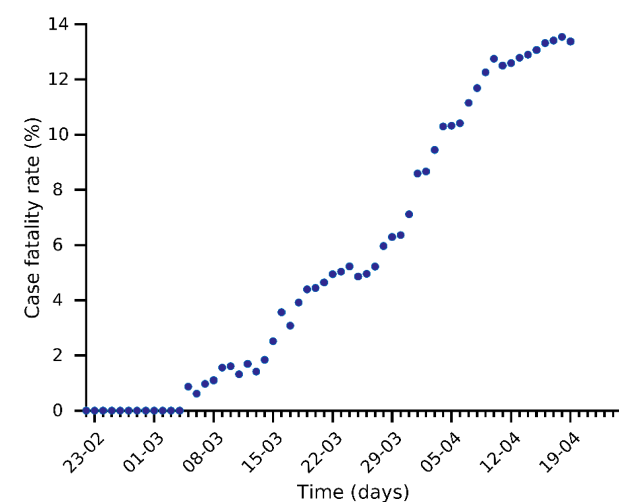
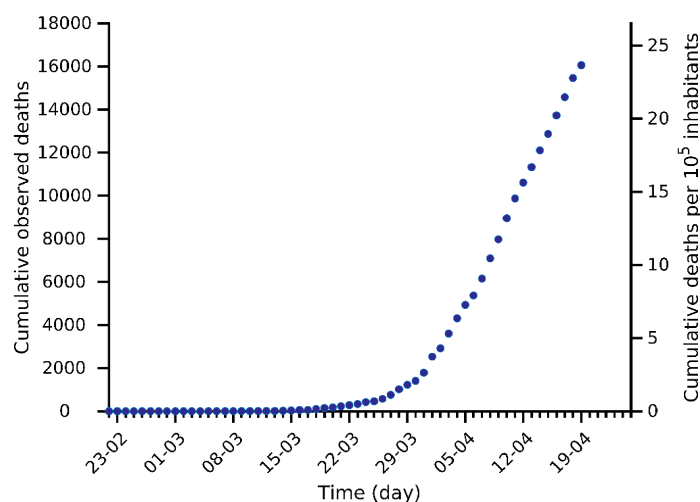
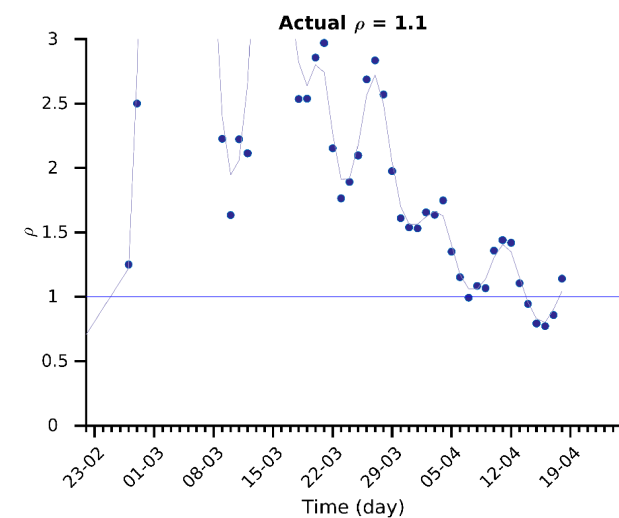
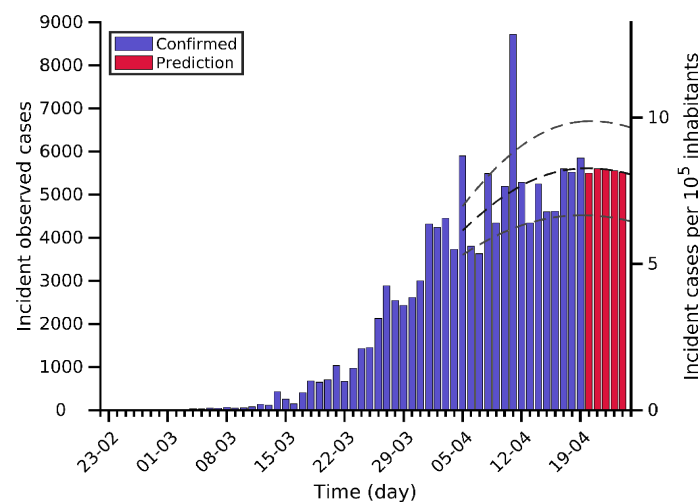
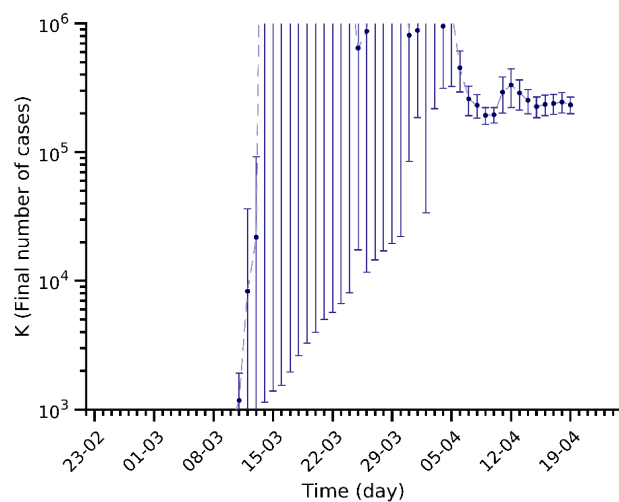
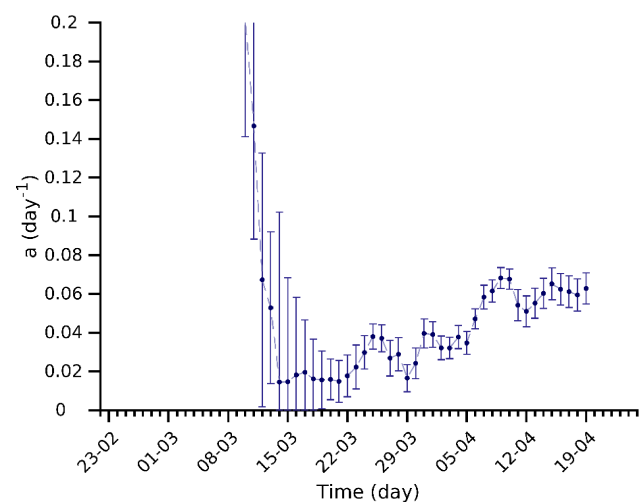
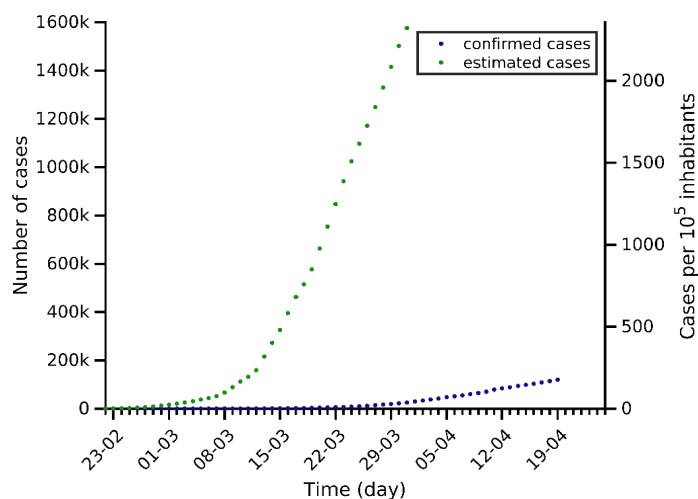
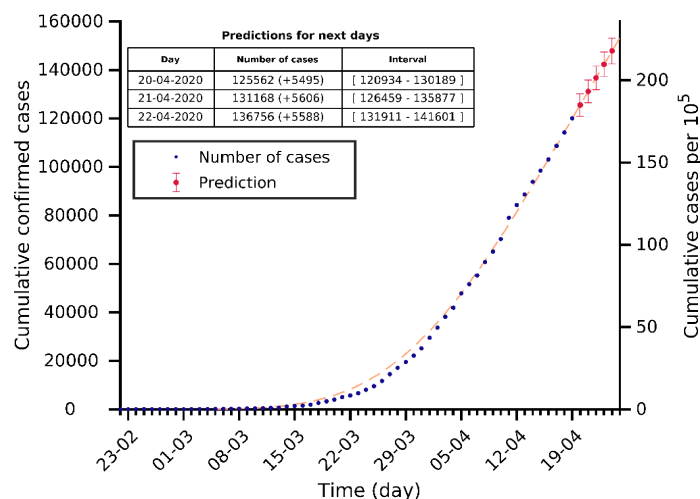
Italy 19-04-2020. Population: 60.5M. Current cumulated incidence: 296/10⁵



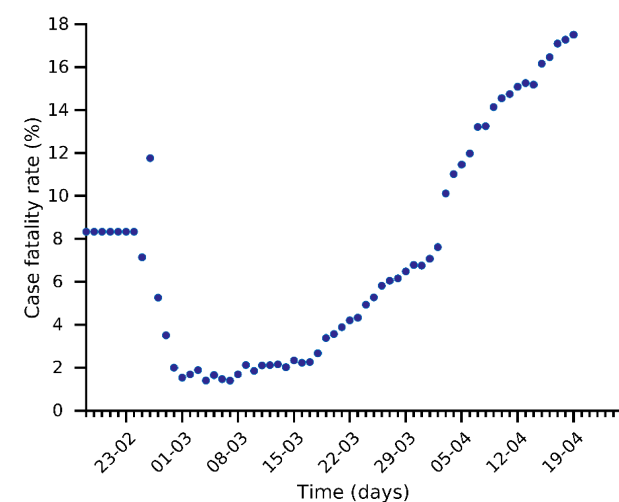
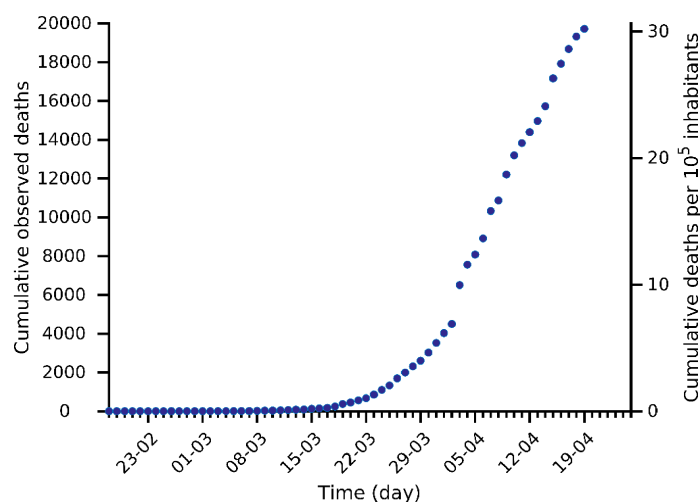
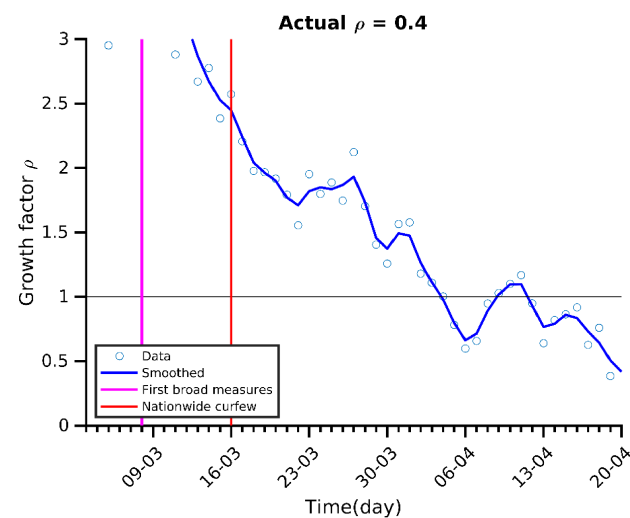
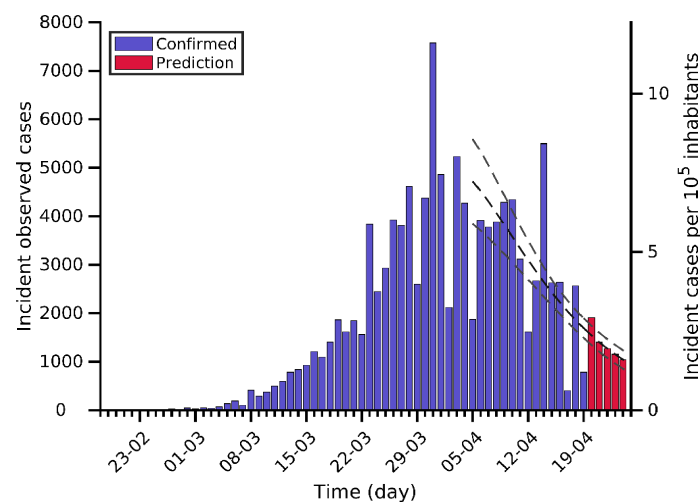
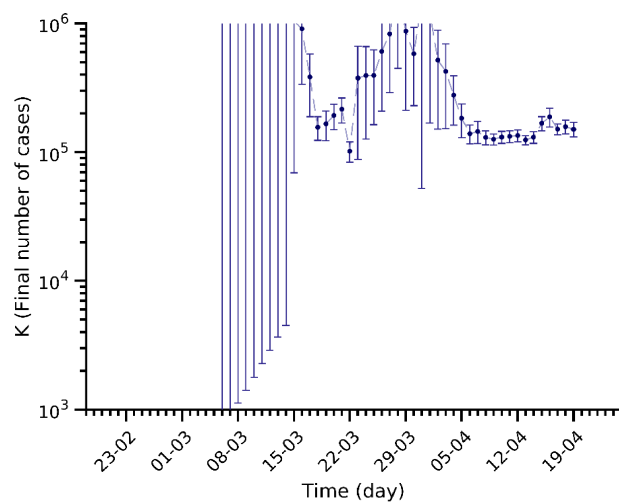
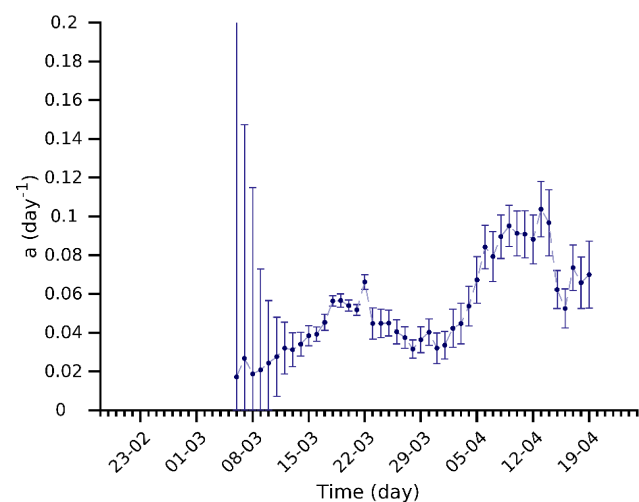
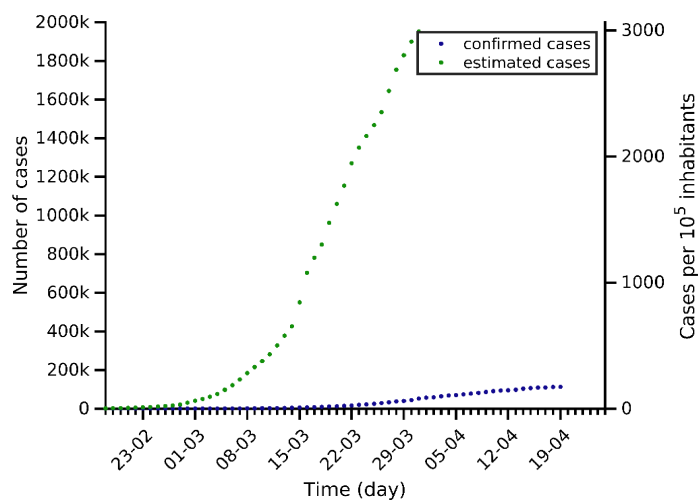
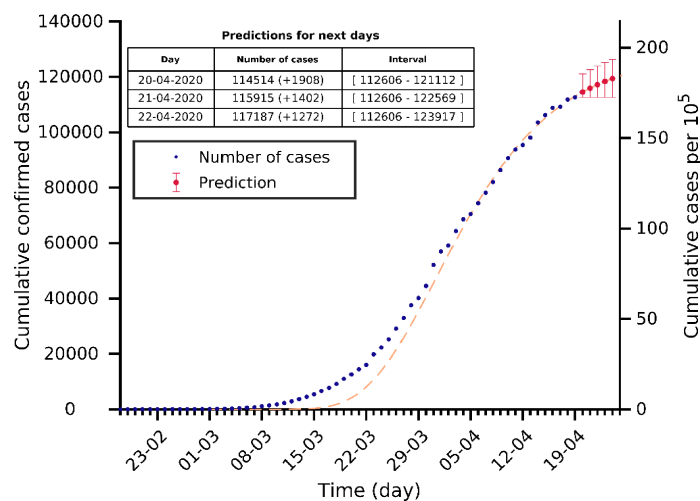
Germany 19-04-2020. Population: 83.8M. Current cumulated incidence: 169/10⁵



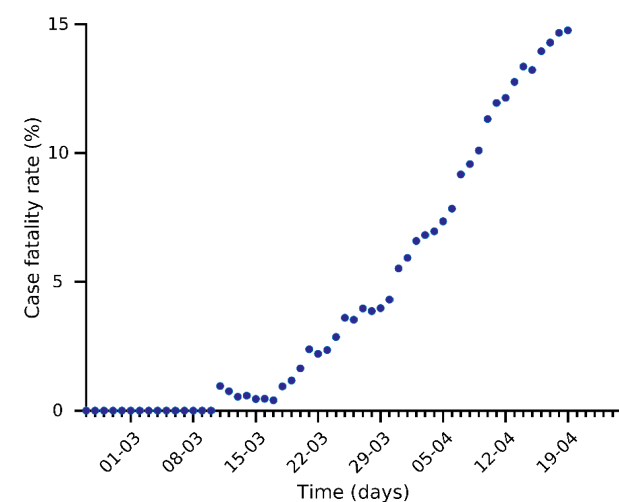
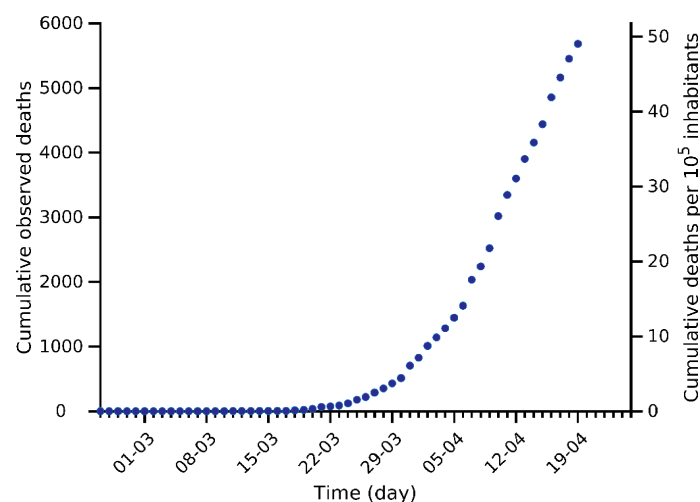
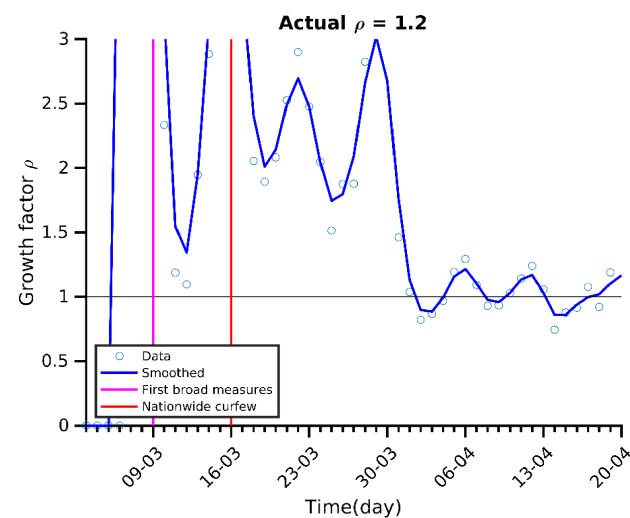
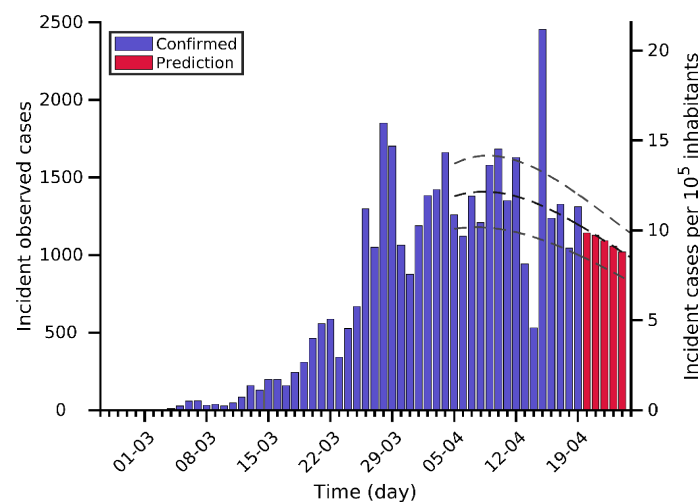
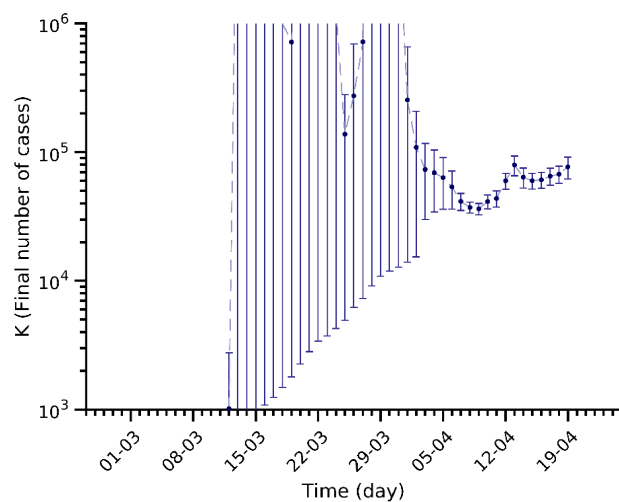
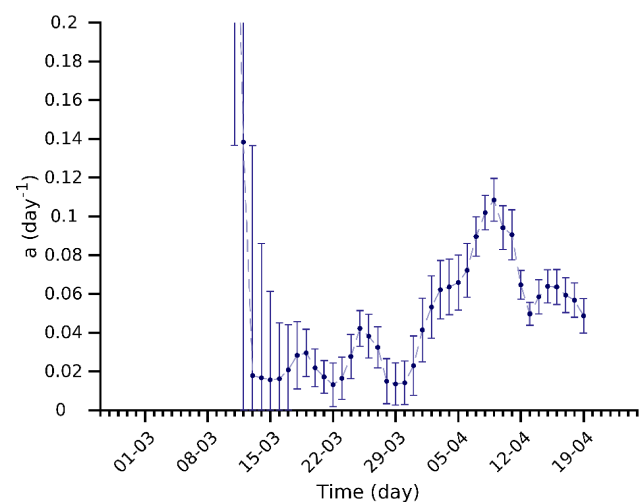
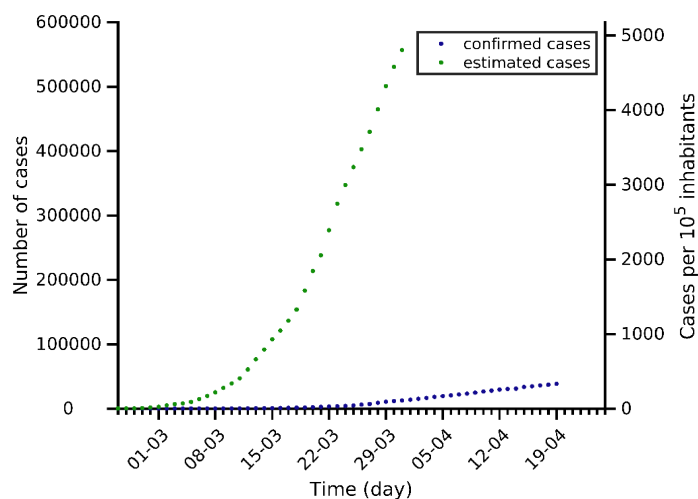
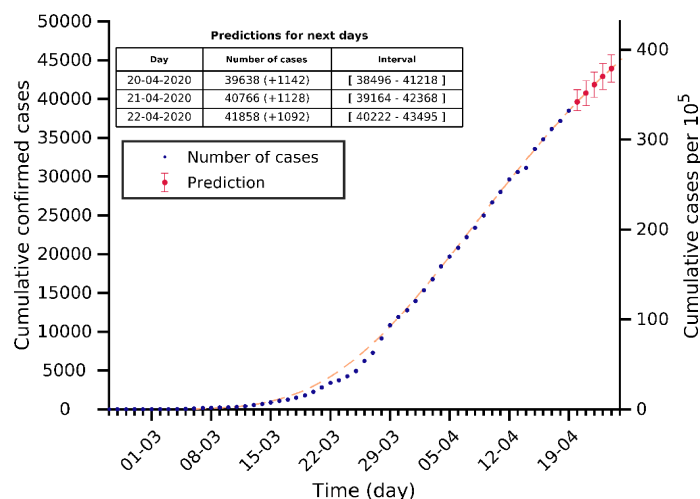
UK 19-04-2020. Population: 67.9M. Current cumulated incidence: 177/10⁵



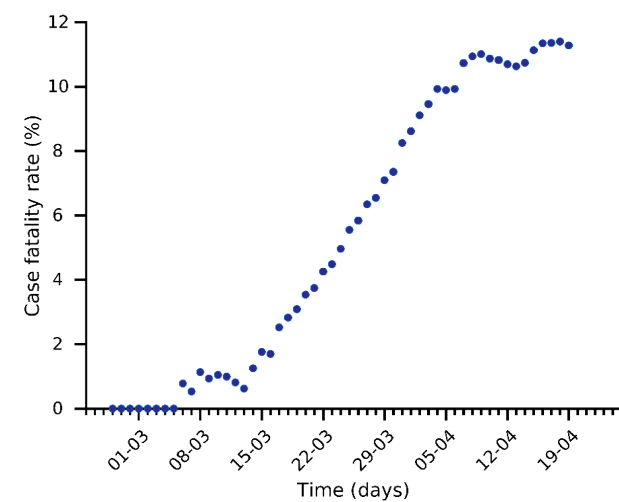
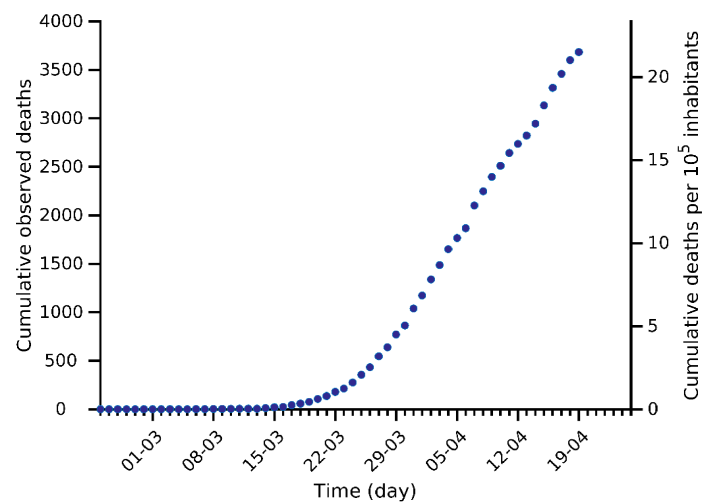
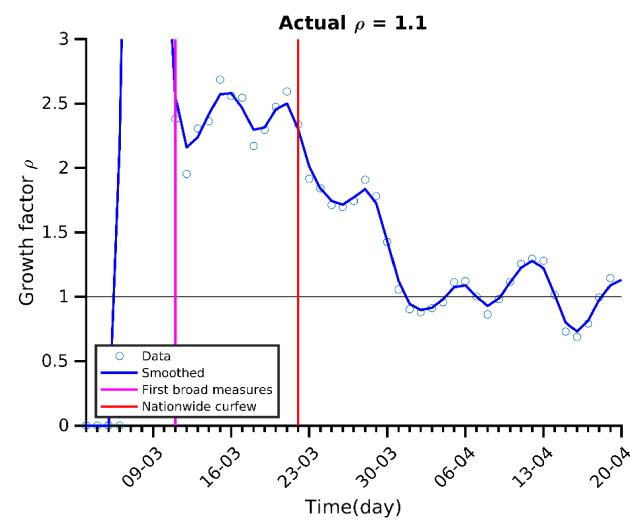
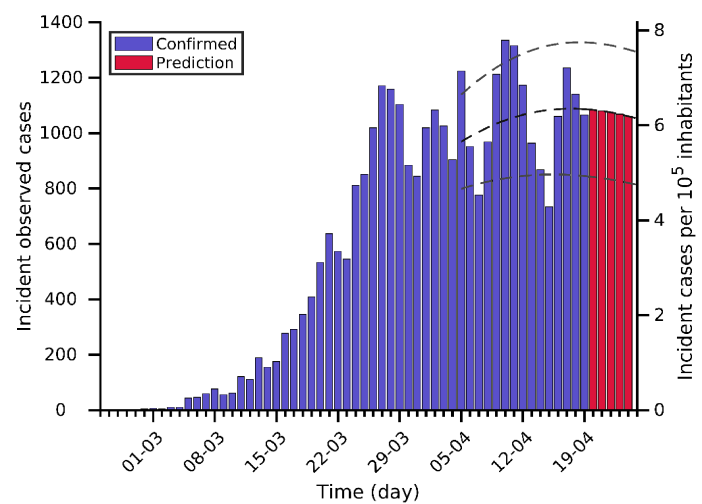
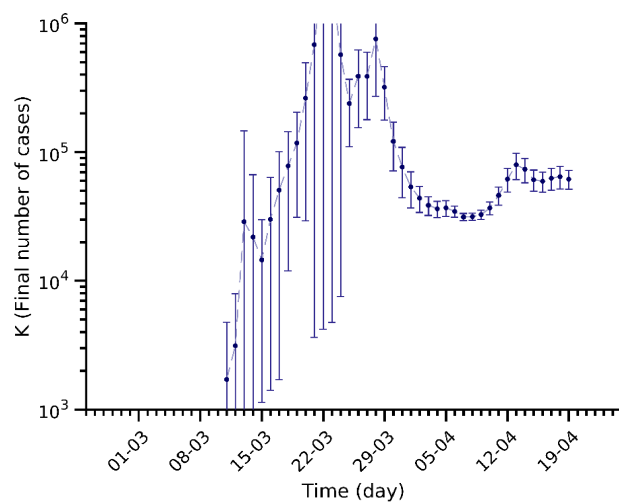
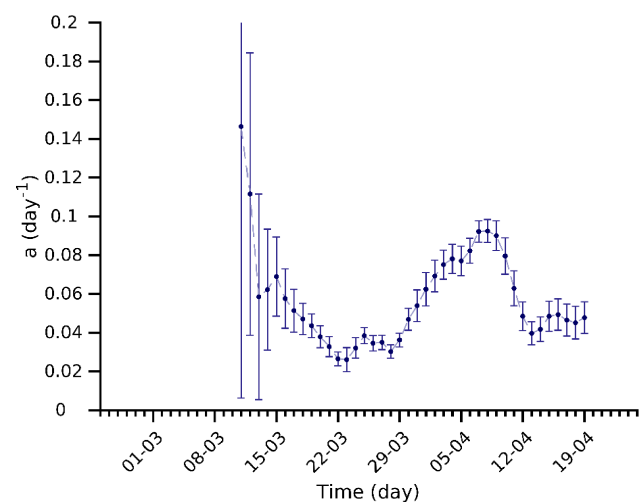
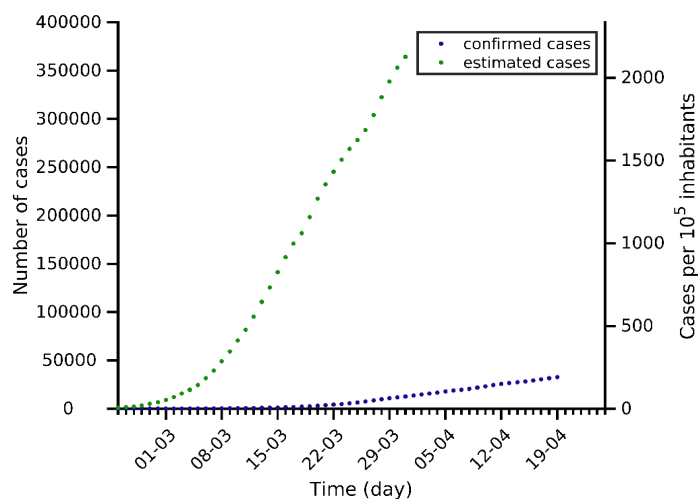
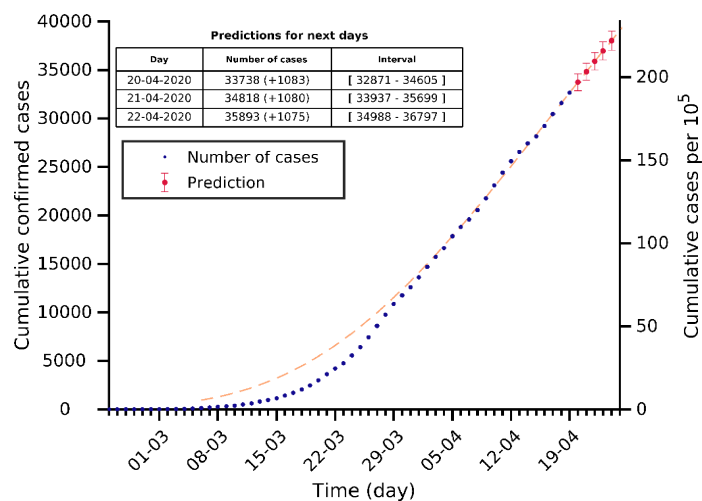
France 19-04-2020. Population: 65.3M. Current cumulated incidence: 173/10⁵



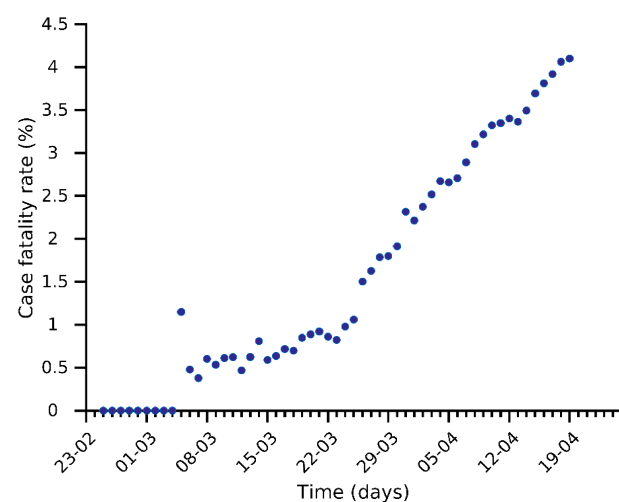
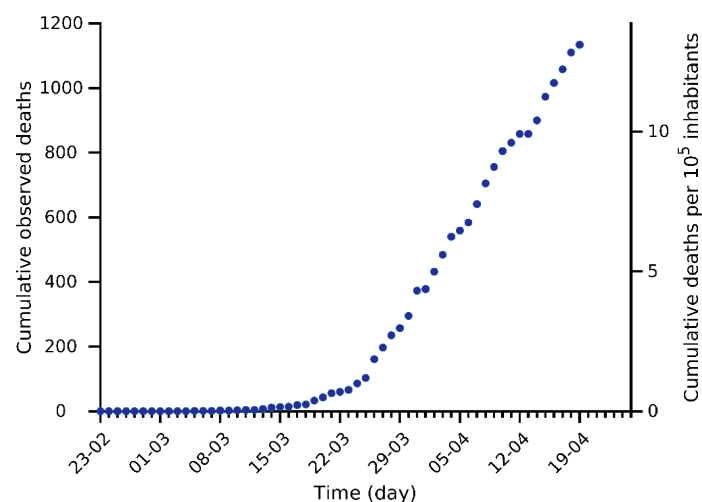
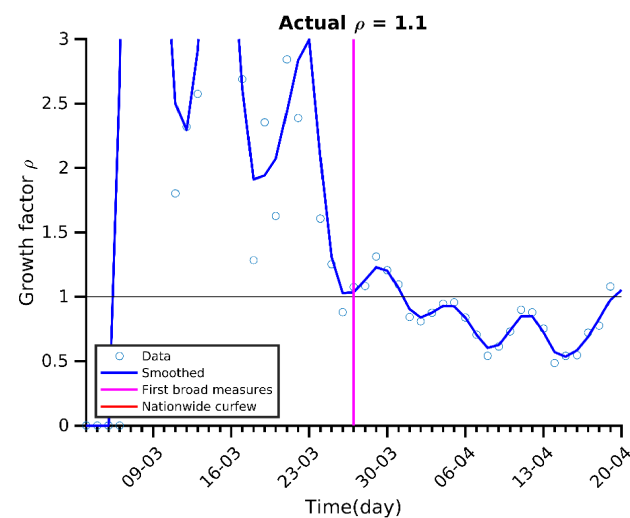
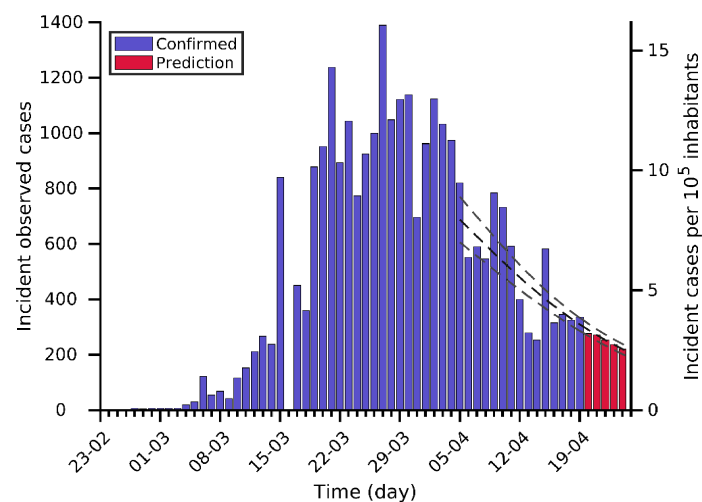
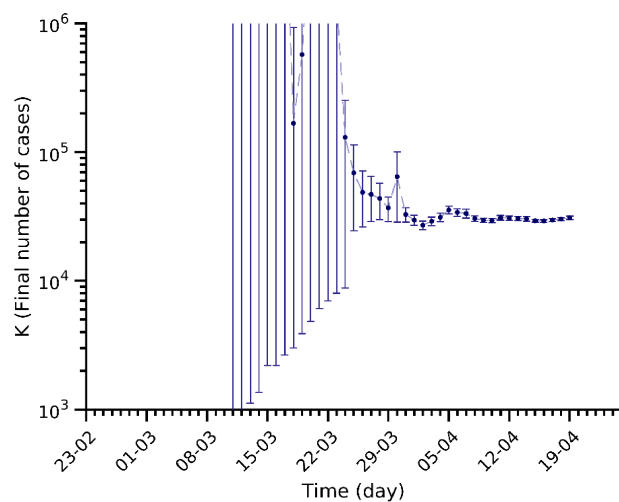
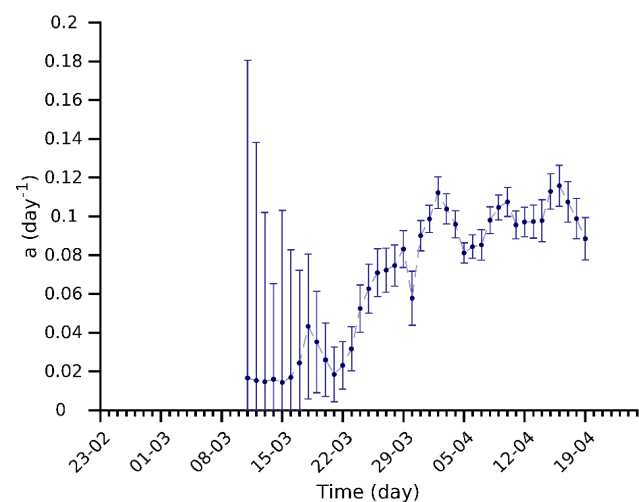
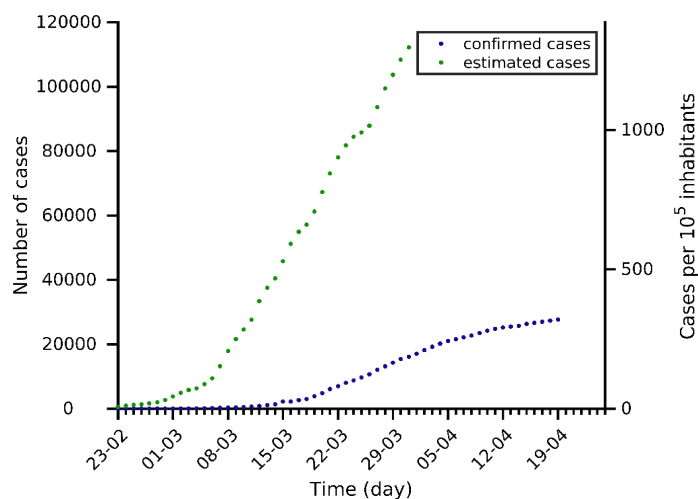
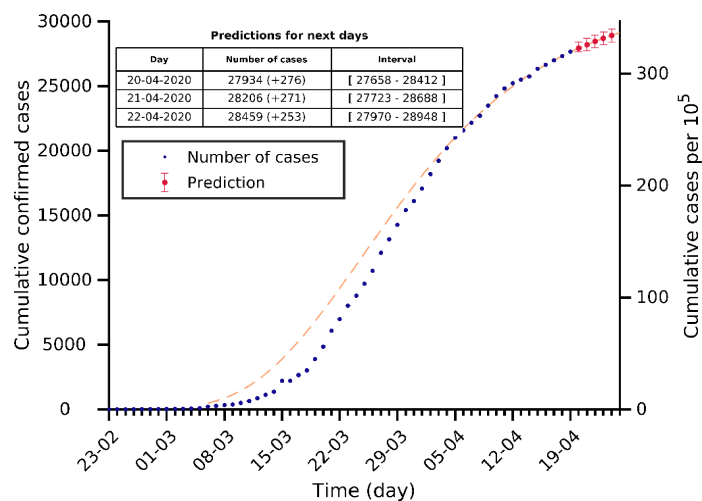
Belgium 19-04-2020. Population: 11.6M. Current cumulated incidence: 332/10⁵



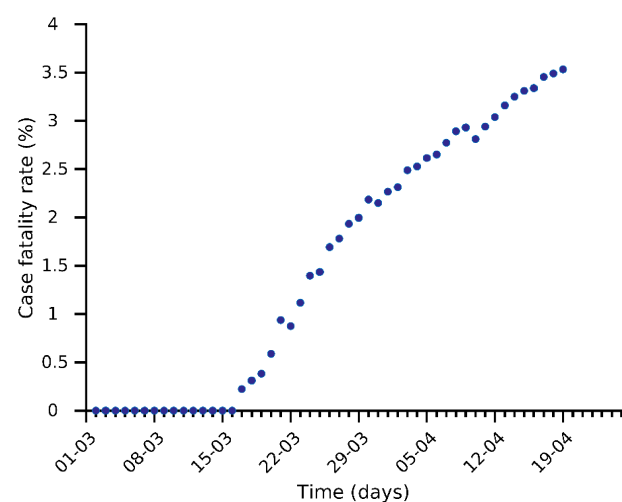
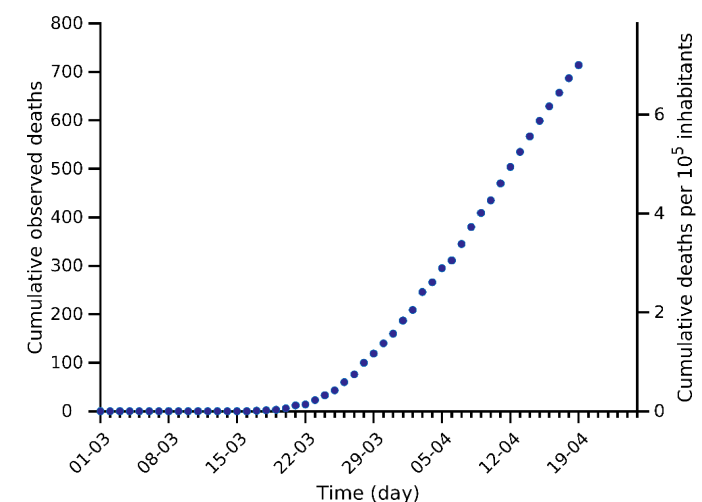
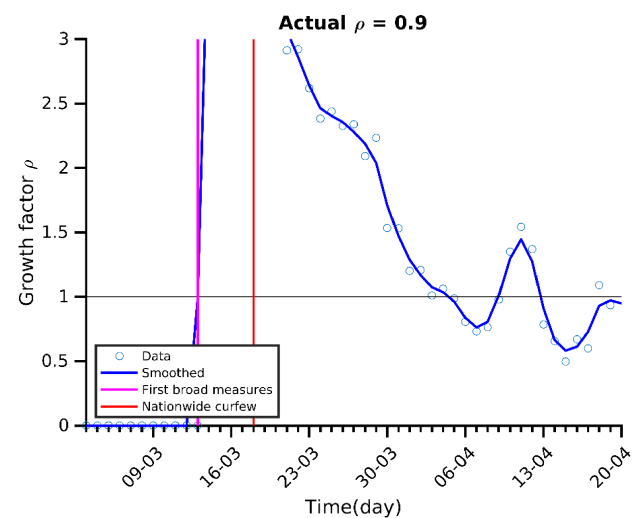
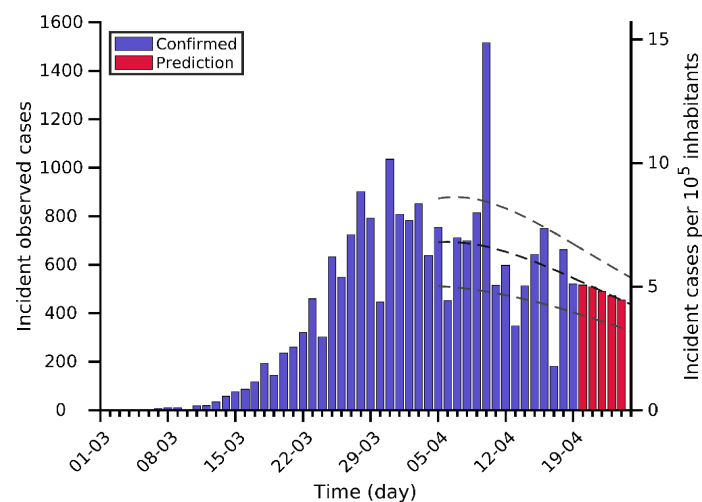
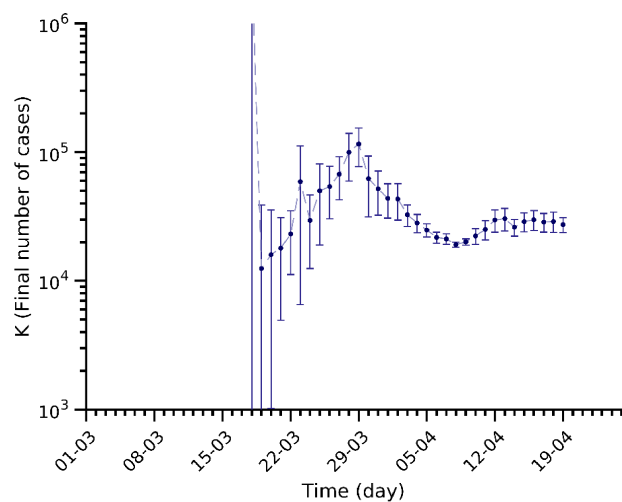
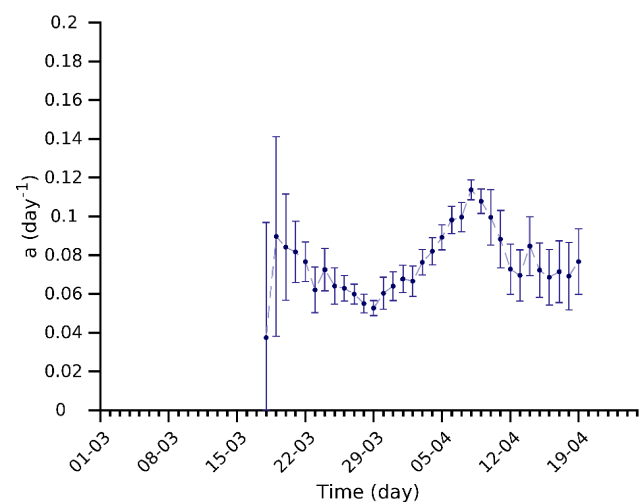
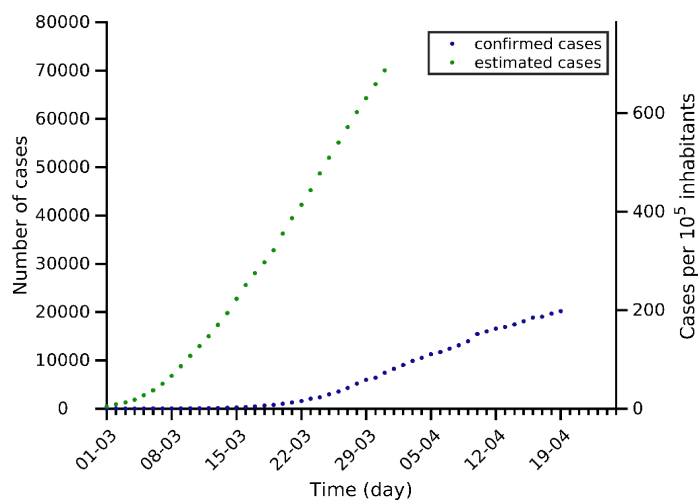
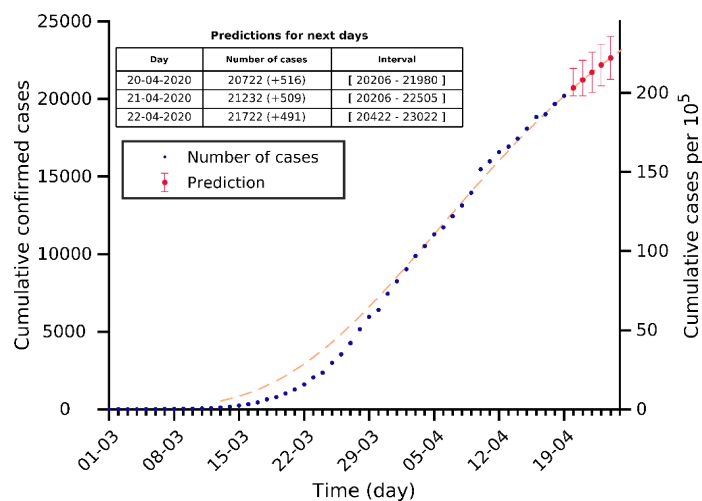
Netherlands 19-04-2020. Population: 17.1M. Current cumulated incidence: 191/10⁵



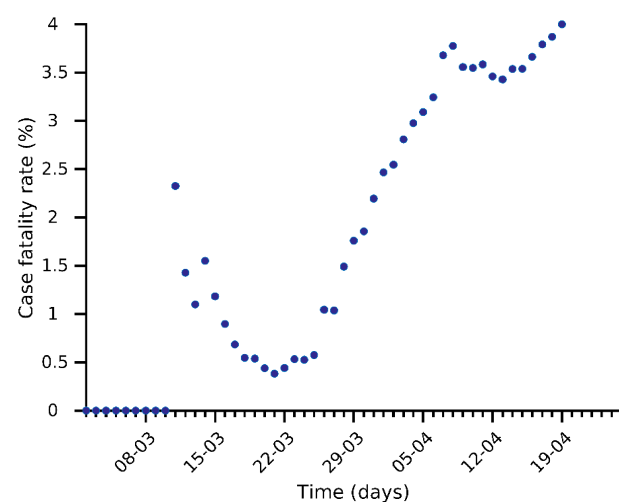
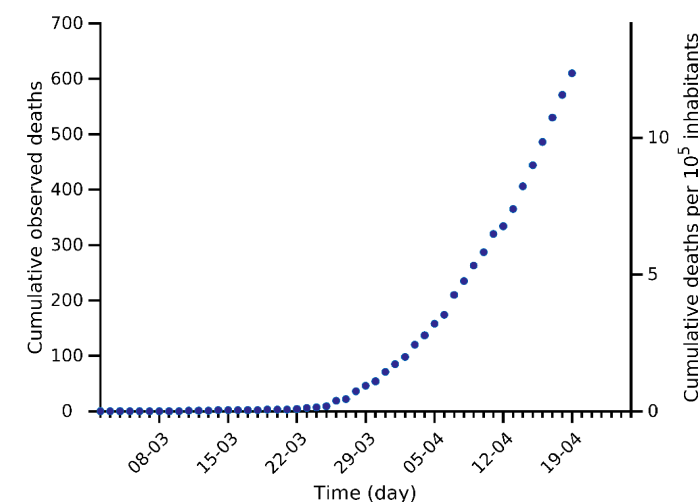
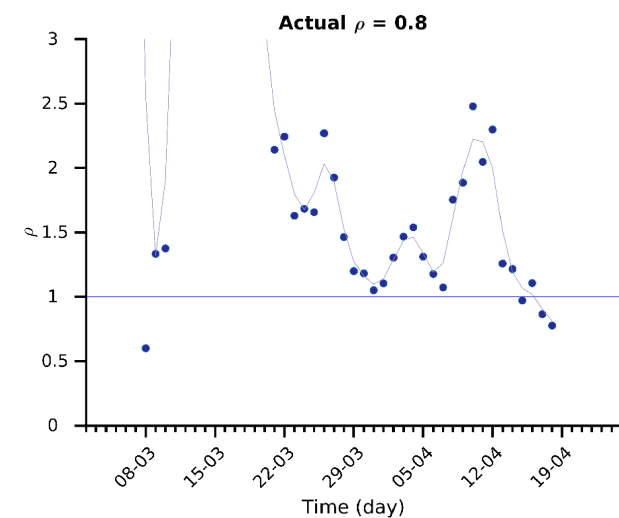
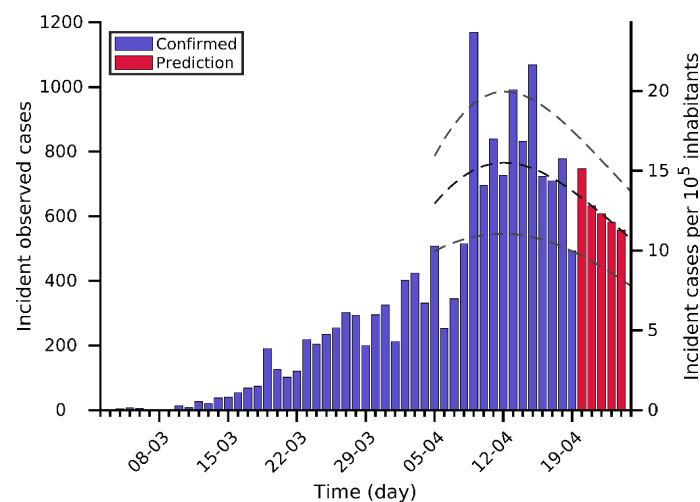
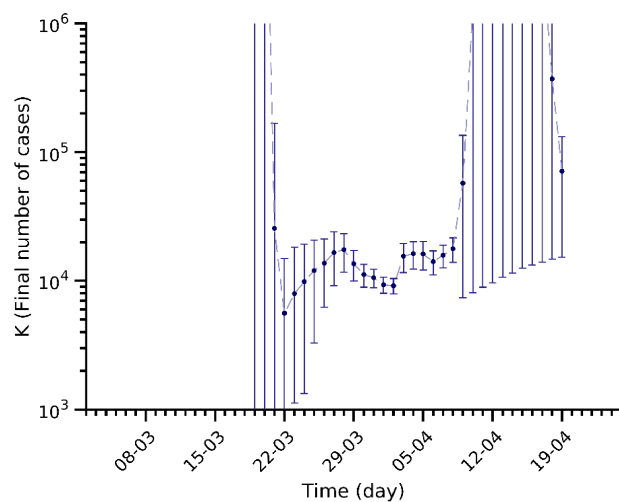
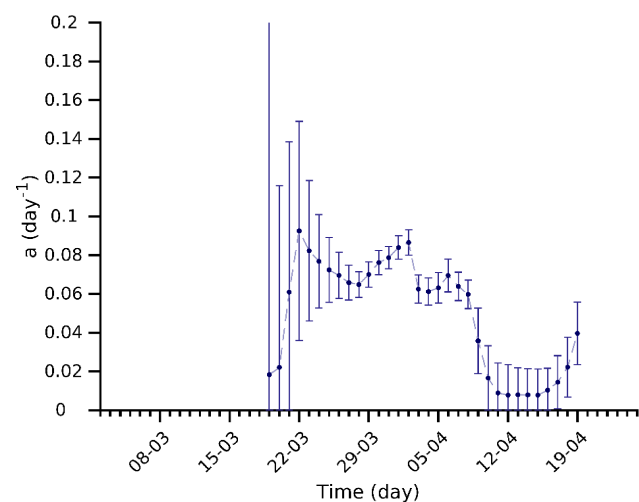
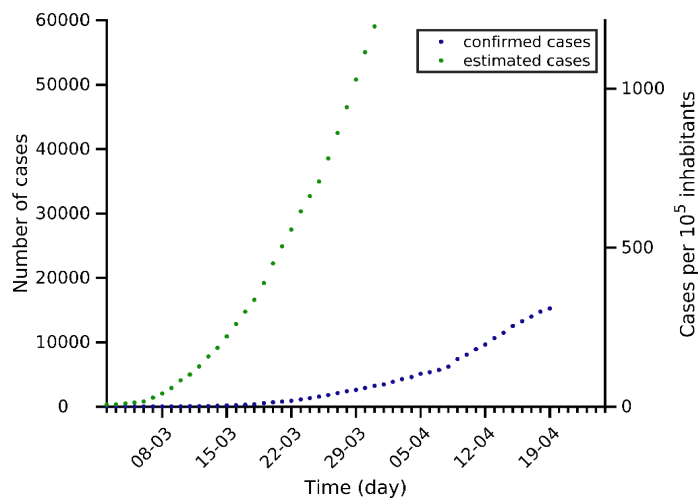
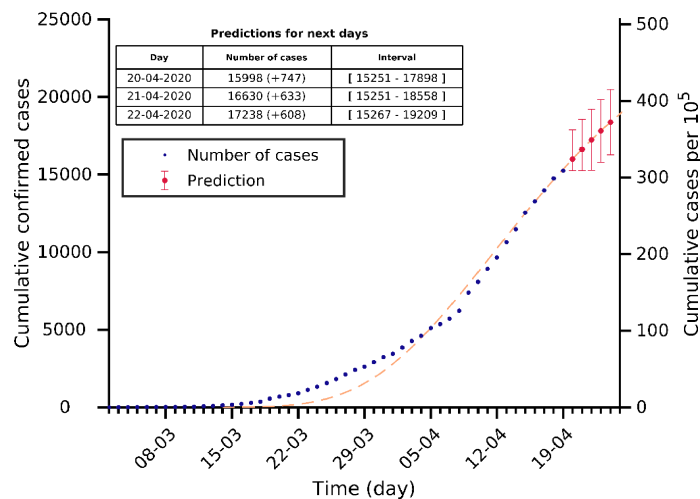
Switzerland 19-04-2020. Population: 8.7M. Current cumulated incidence: 320/10⁵



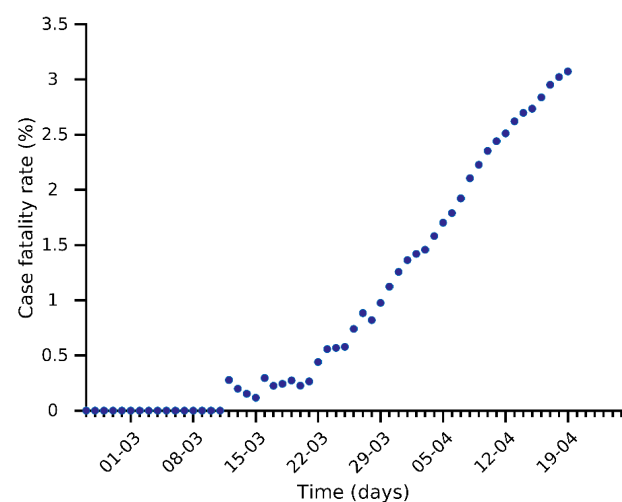
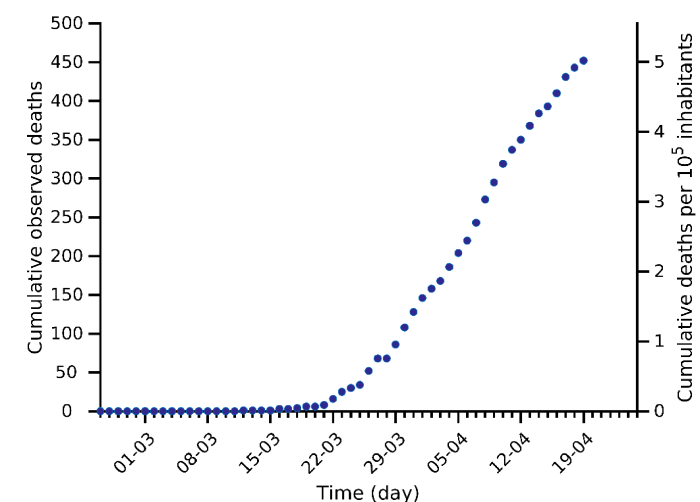
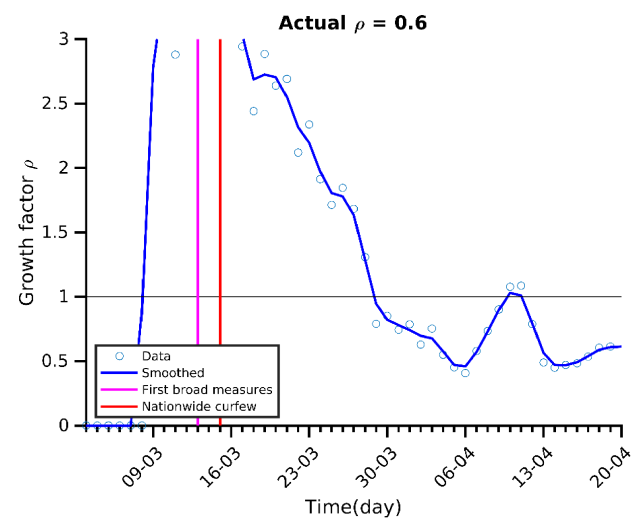
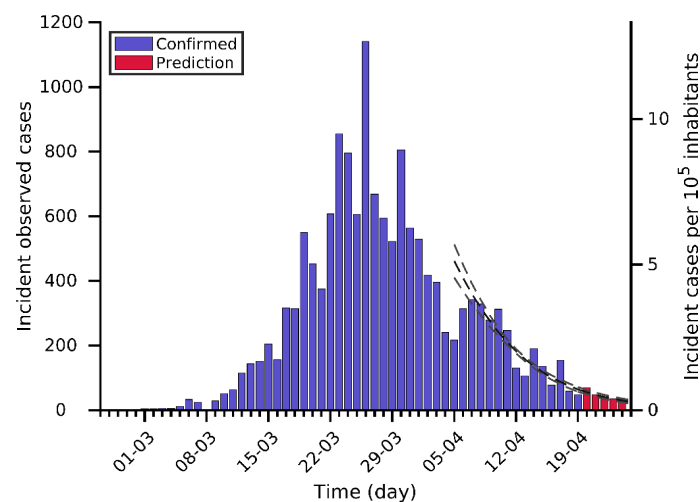
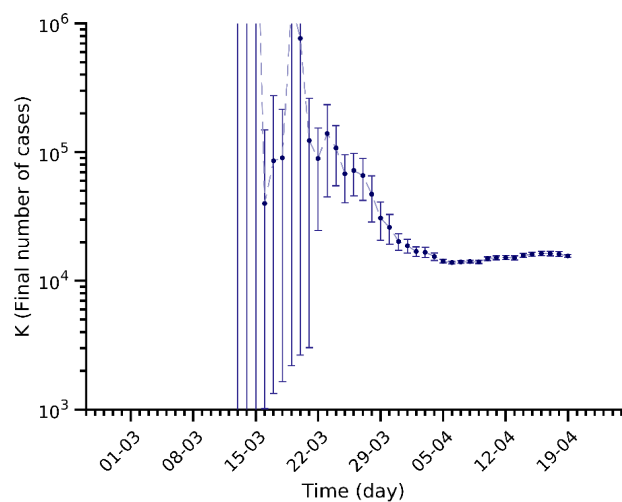
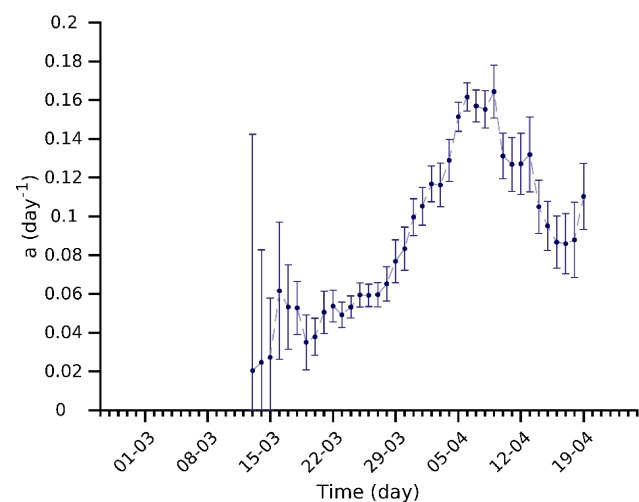
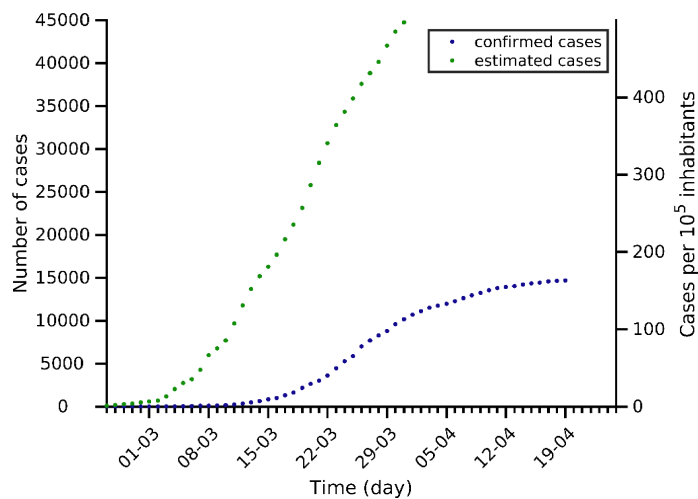
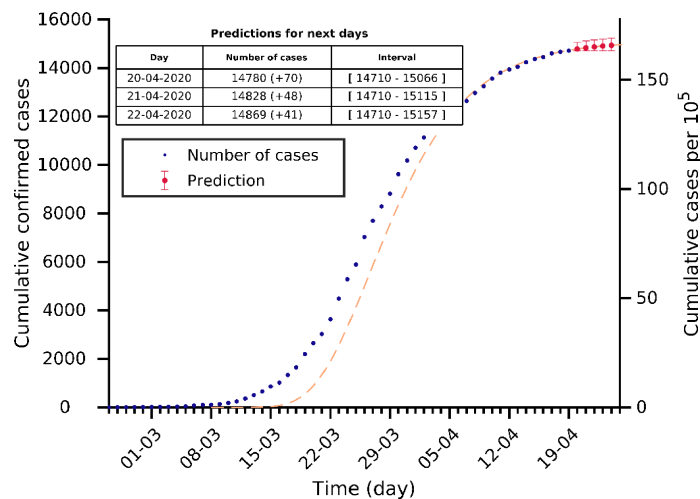
Portugal 19-04-2020. Population: 10.2M. Current cumulated incidence: 198/10⁵



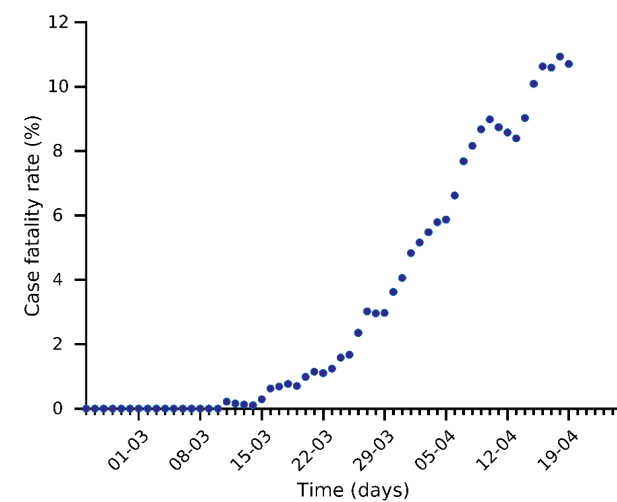
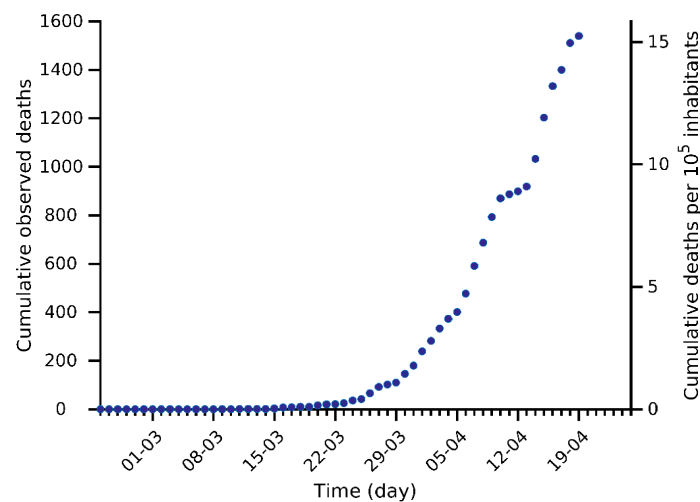
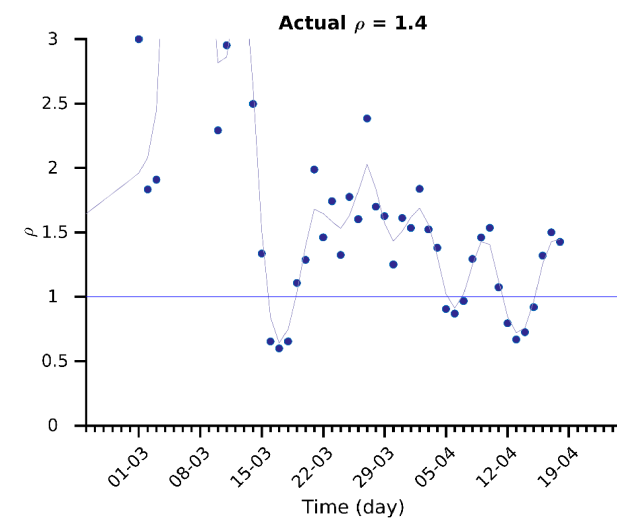
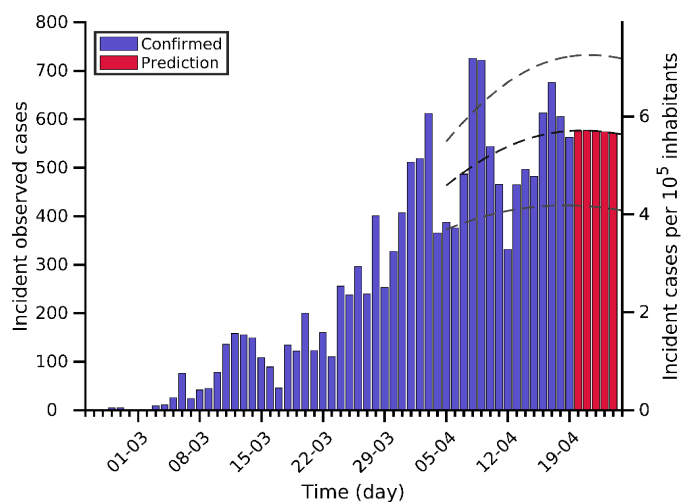
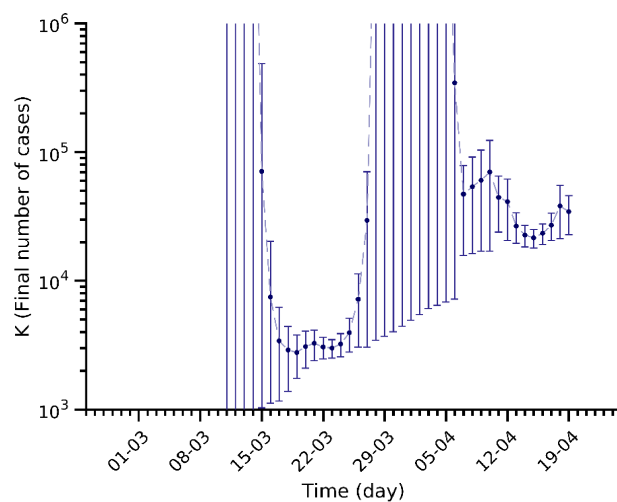
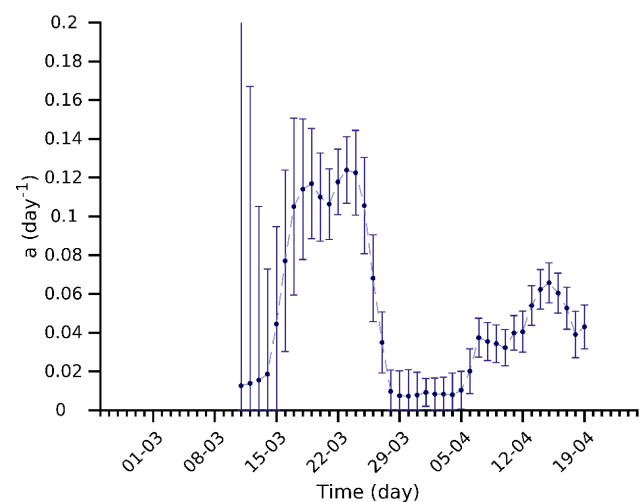
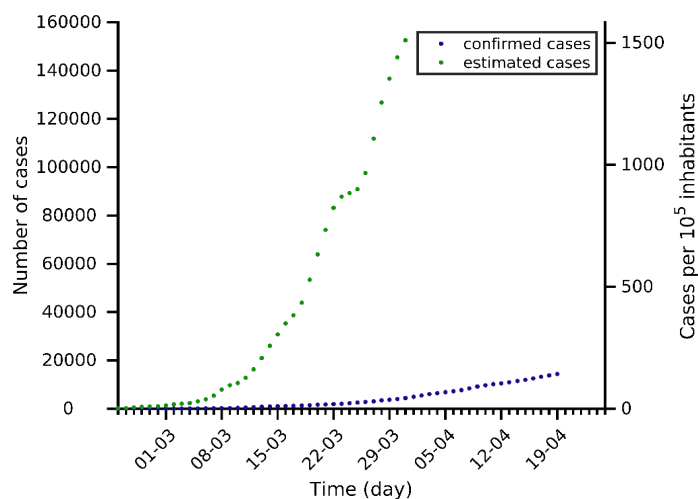
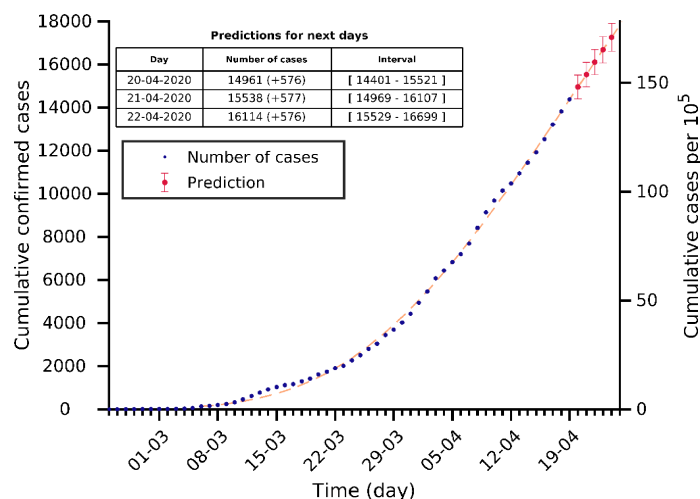
Ireland 19-04-2020. Population: 4.9M. Current cumulated incidence: 309/10⁵



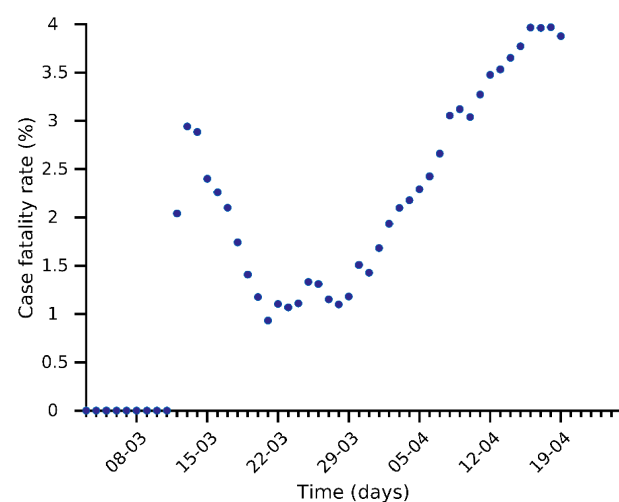
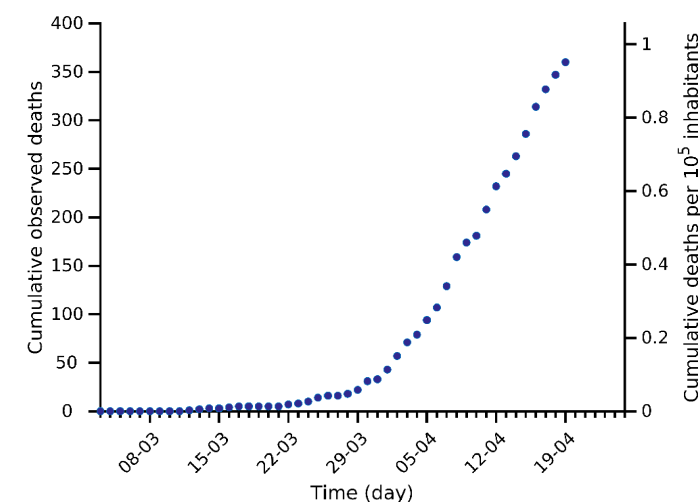
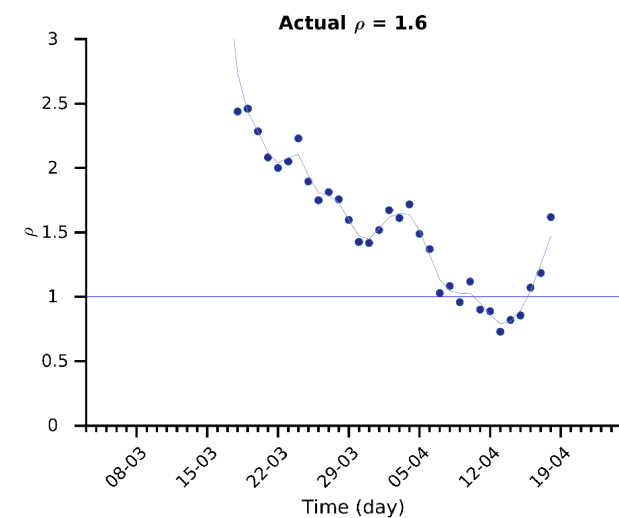
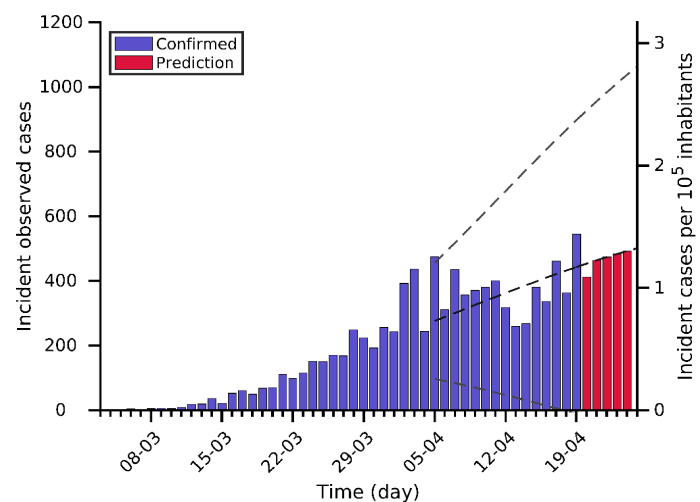
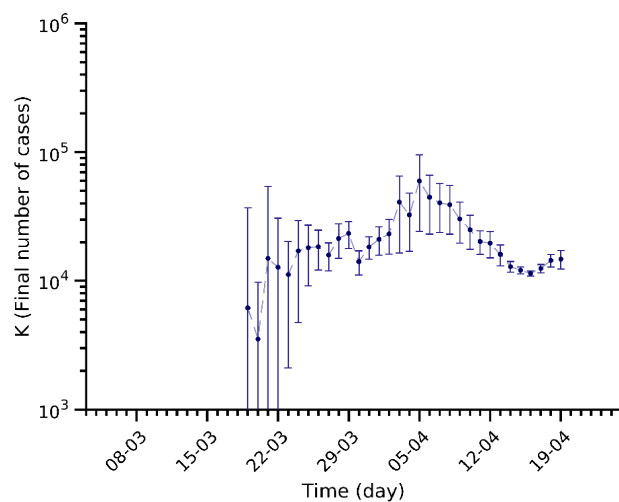
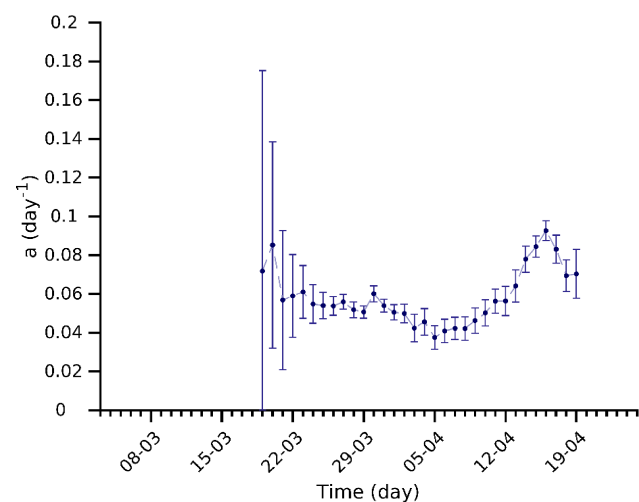
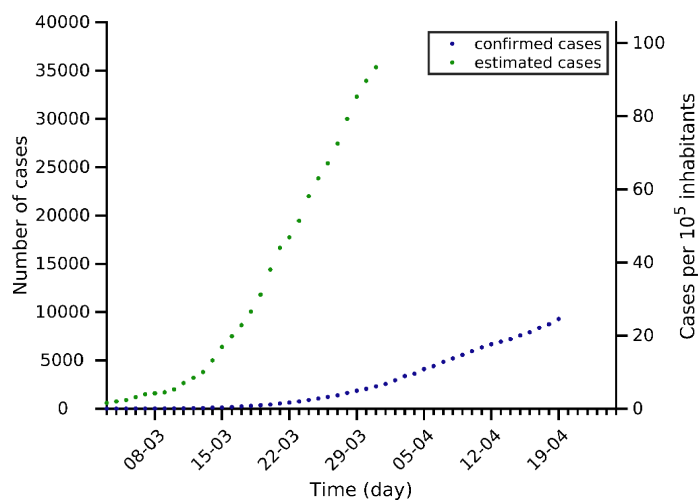
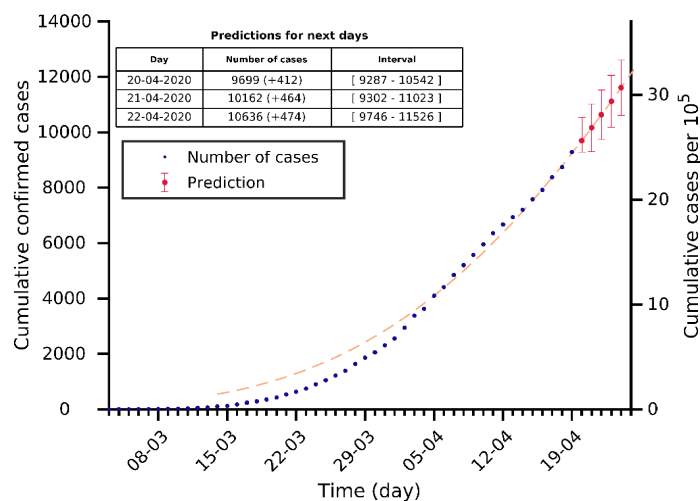
Austria 19-04-2020. Population: 9.0M. Current cumulated incidence: 163/10⁵



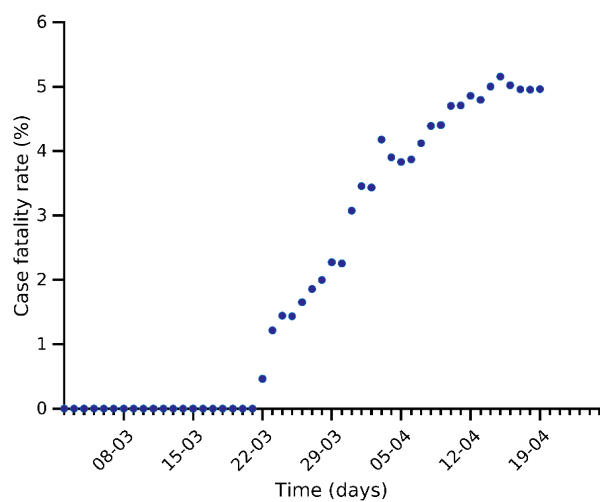
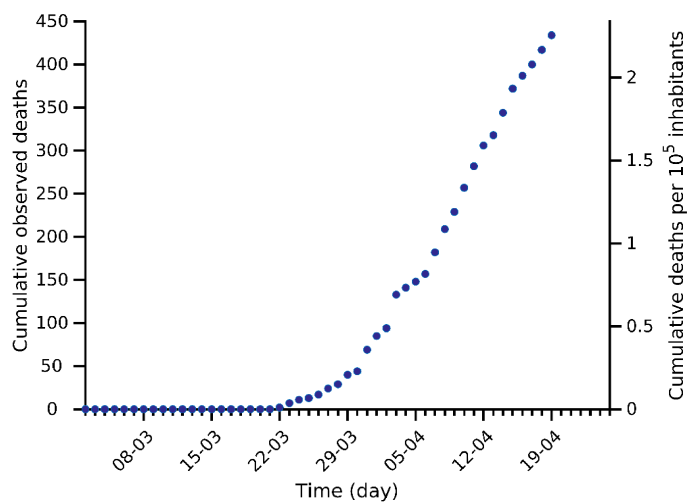
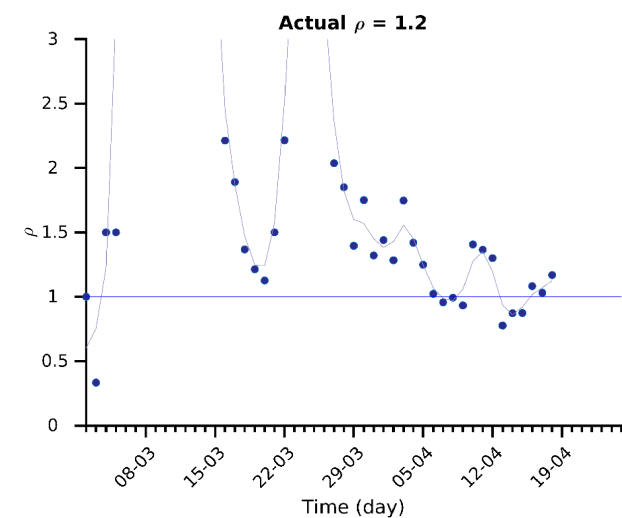
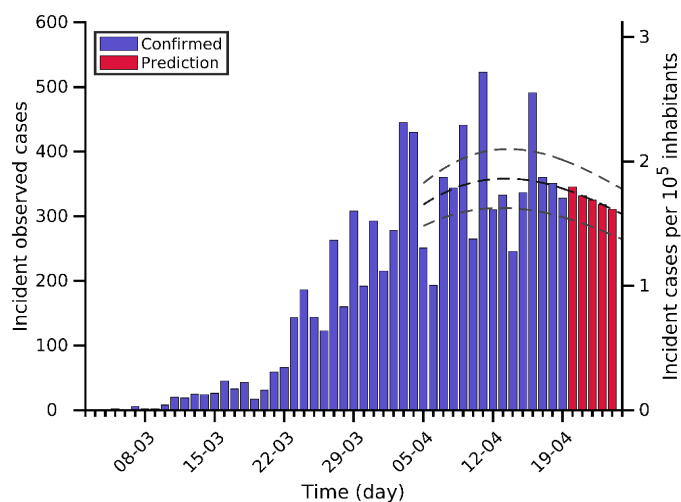
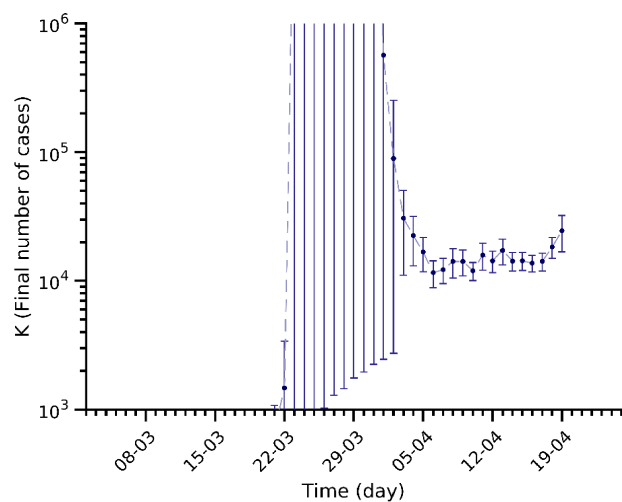
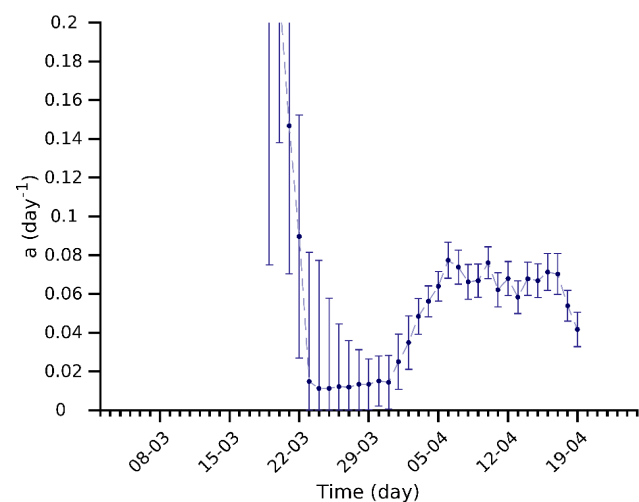
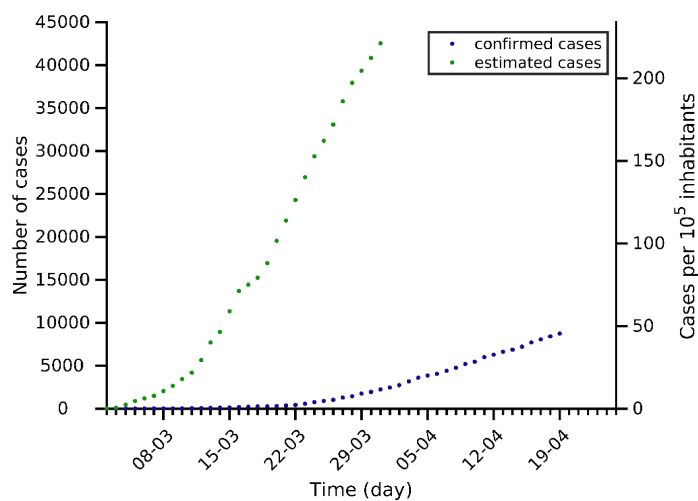
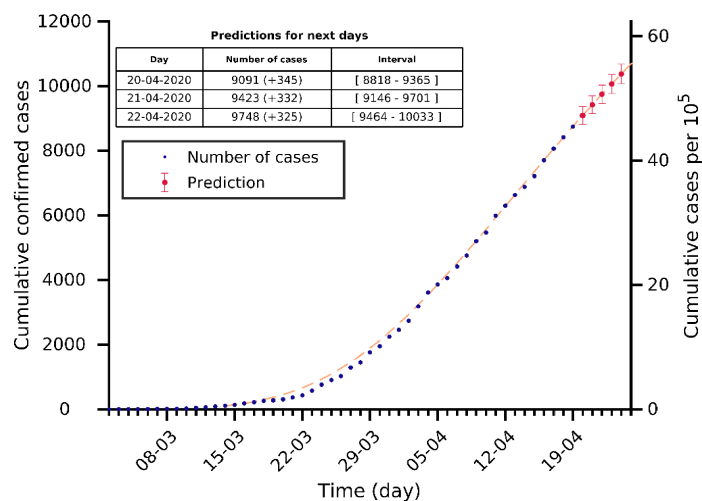
Sweden 19-04-2020. Population: 10.1M. Current cumulated incidence: 142/10⁵



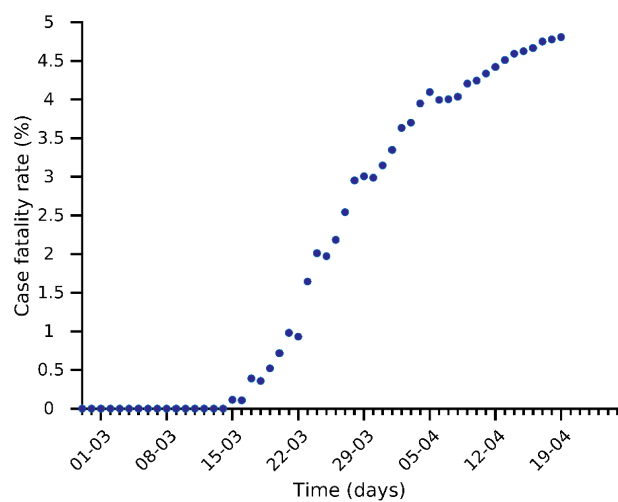
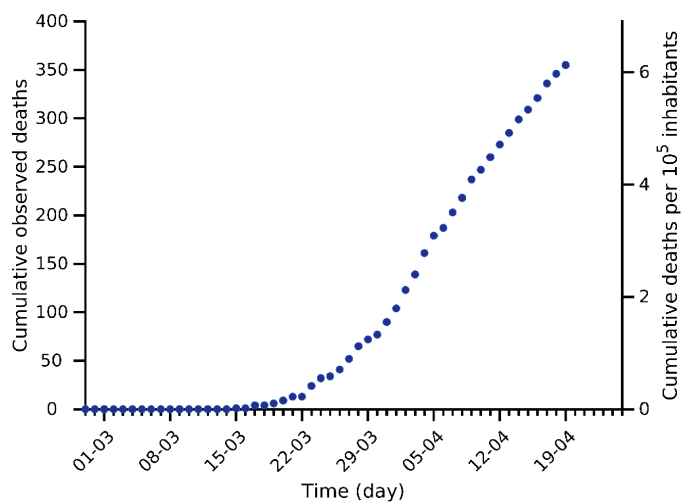
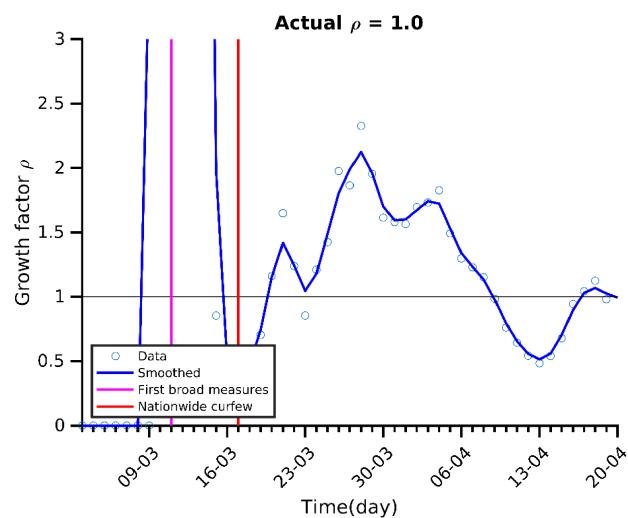
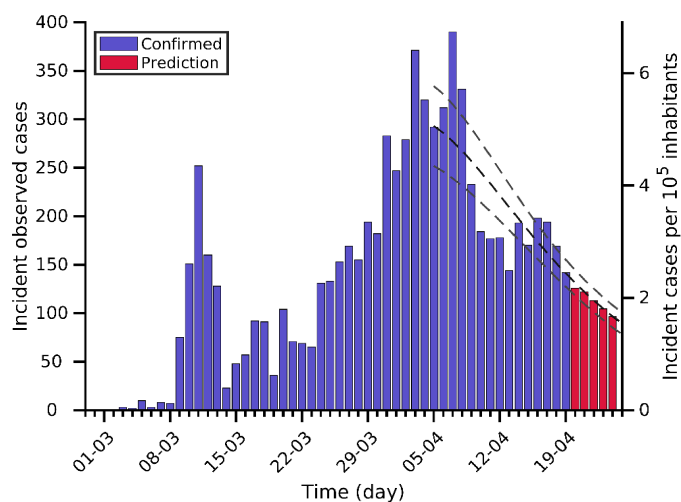
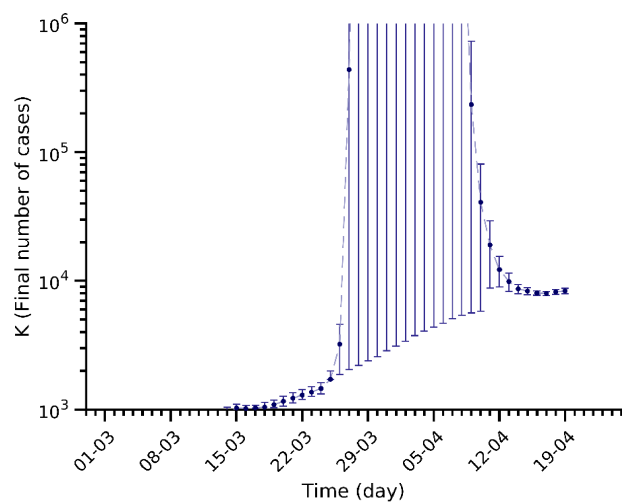
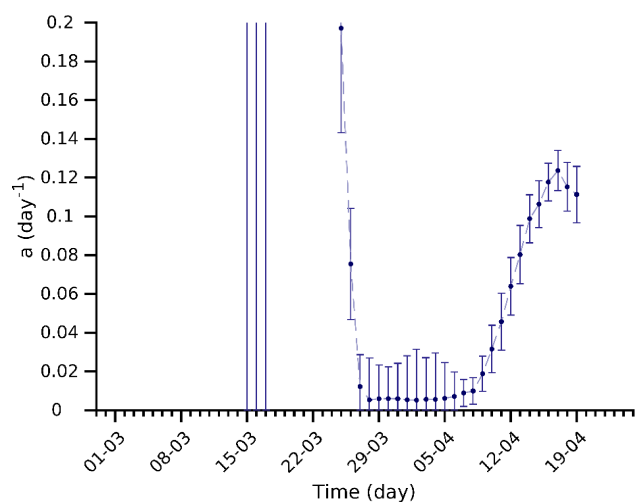
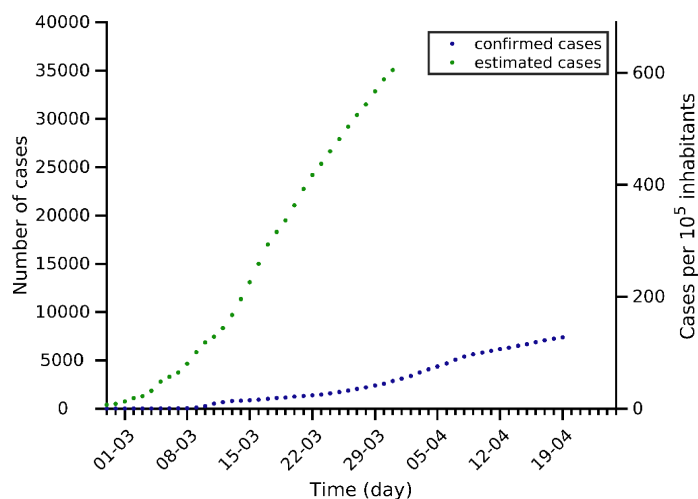
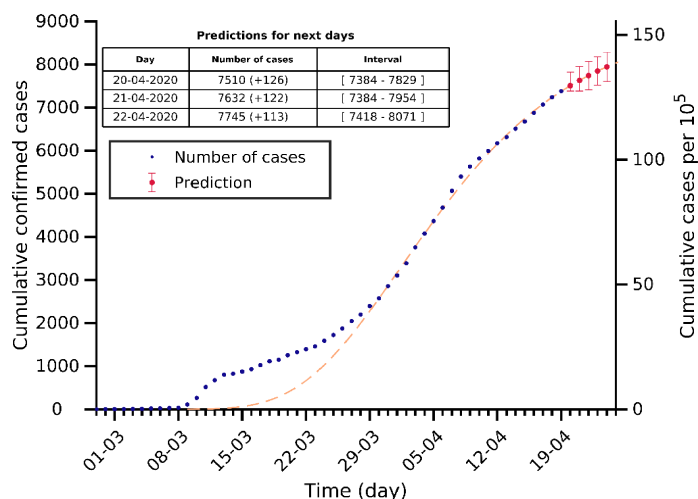
Poland 19-04-2020. Population: 37.8M. Current cumulated incidence: 25/10⁵



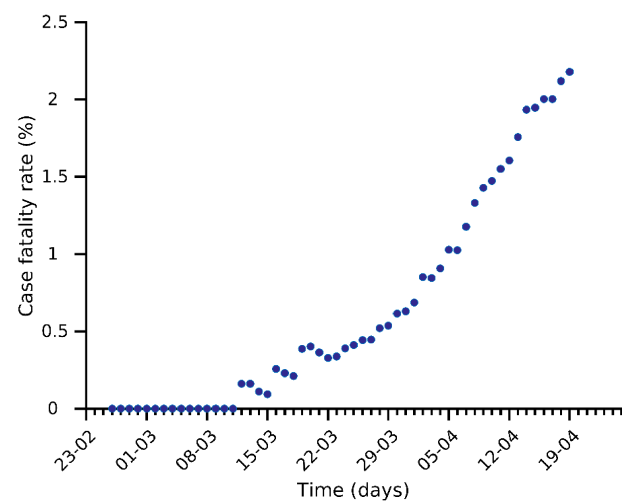
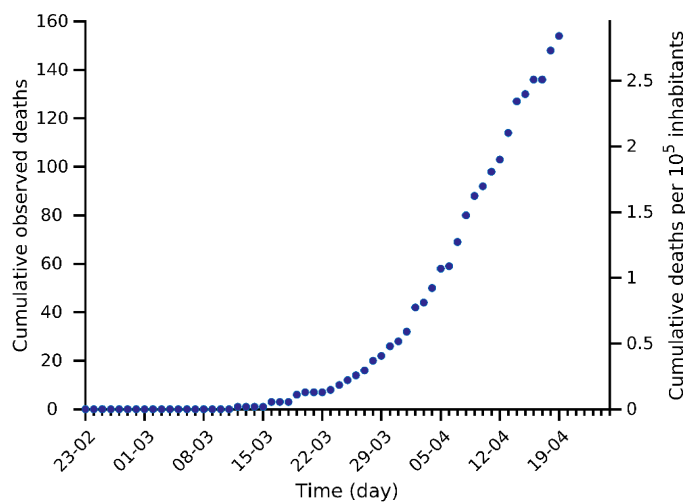
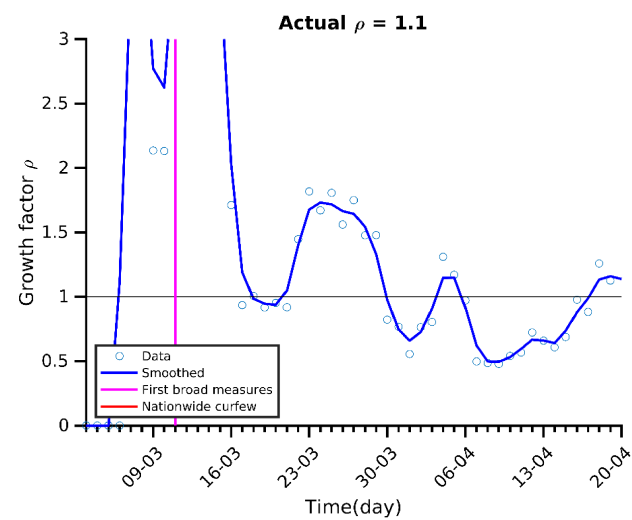
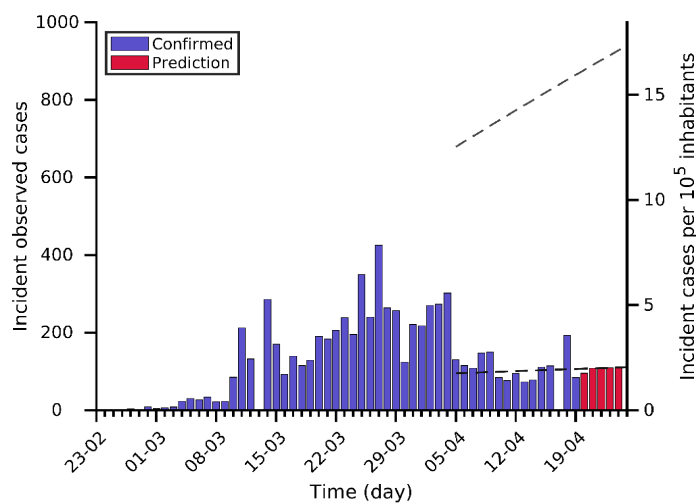
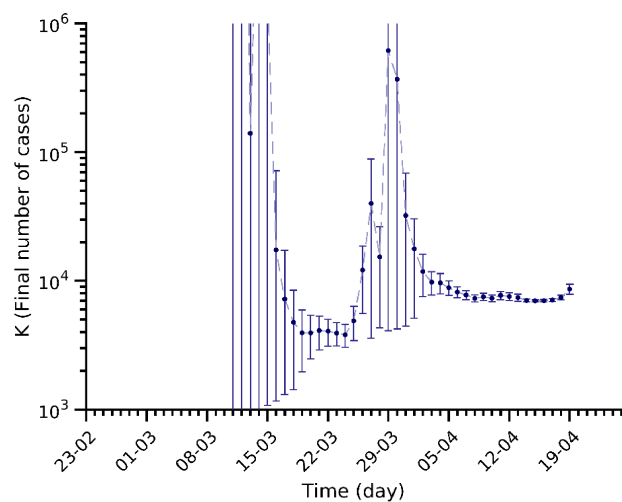
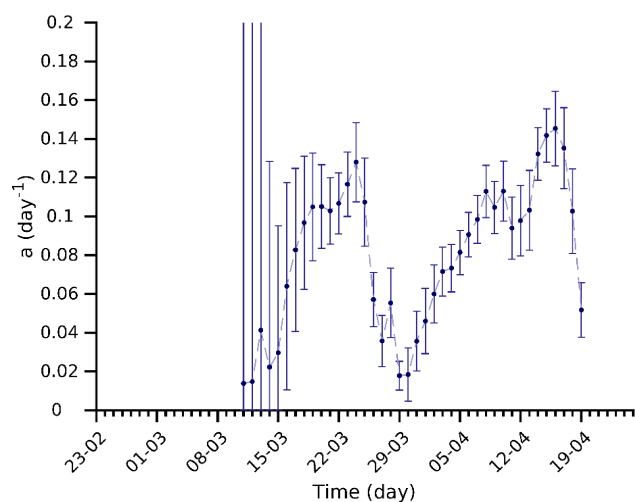
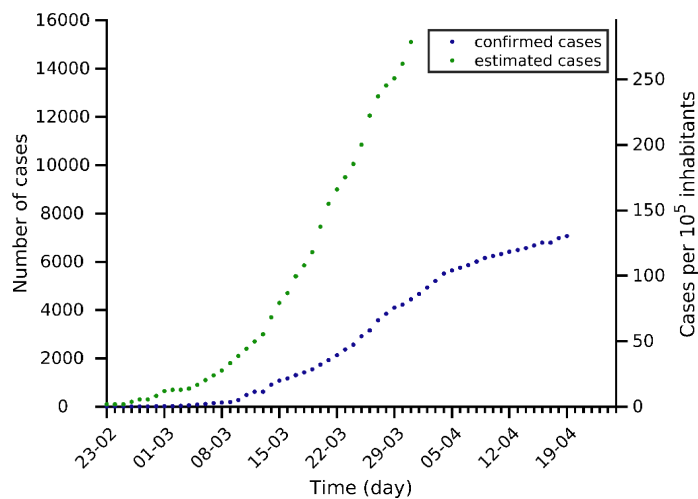
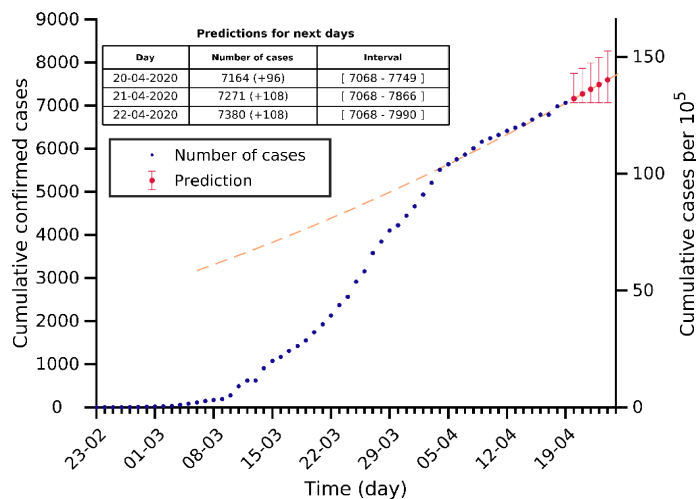
Romania 19-04-2020. Population: 19.2M. Current cumulated incidence: 45/10⁵



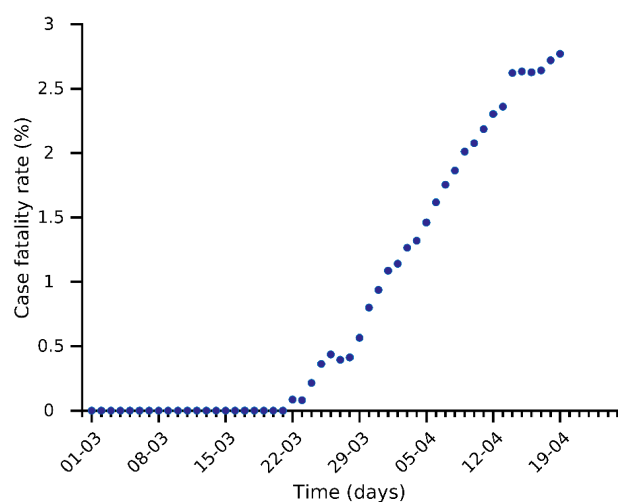
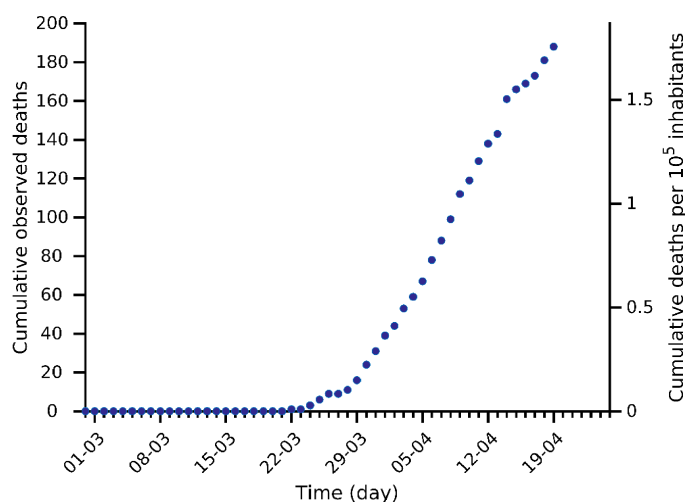
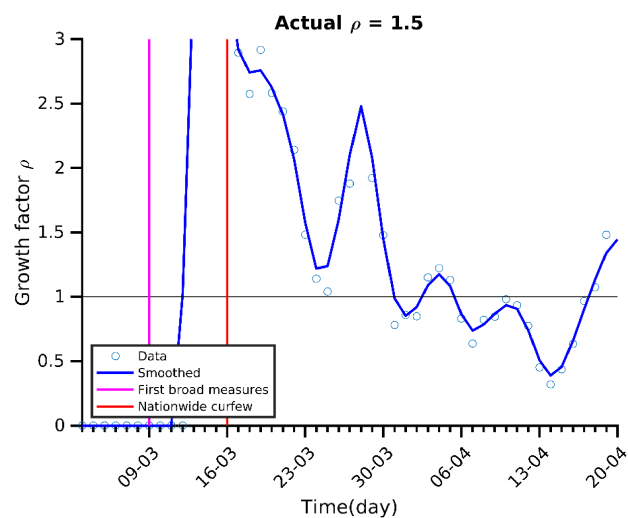
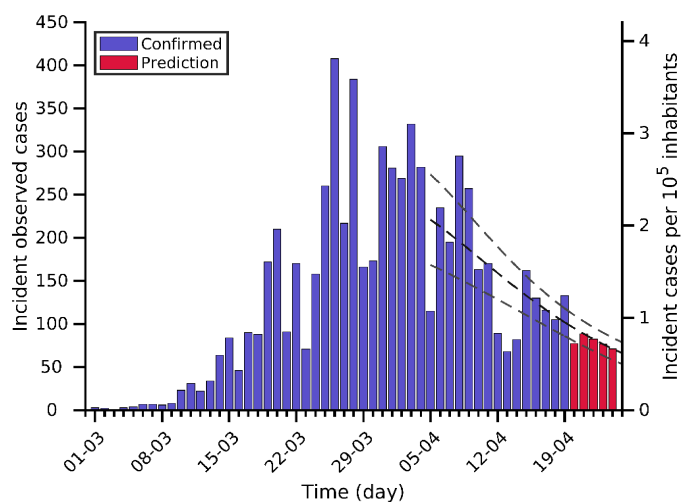
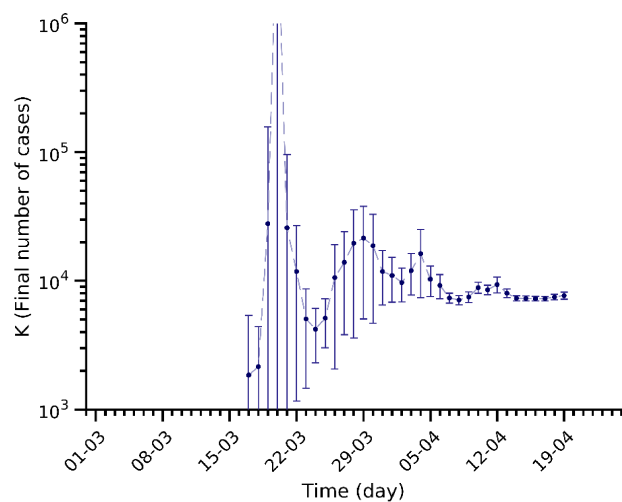
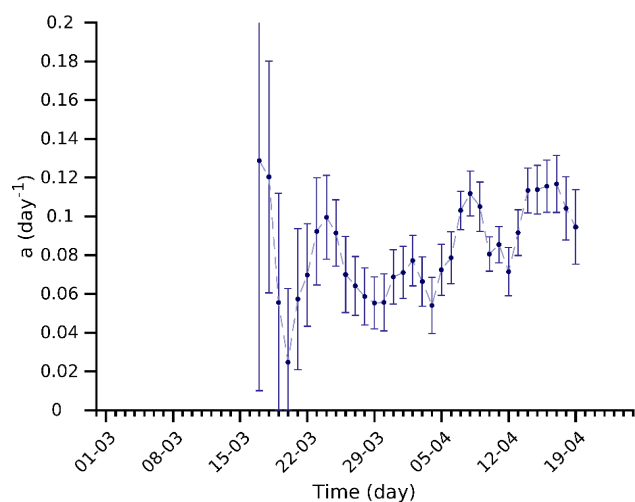
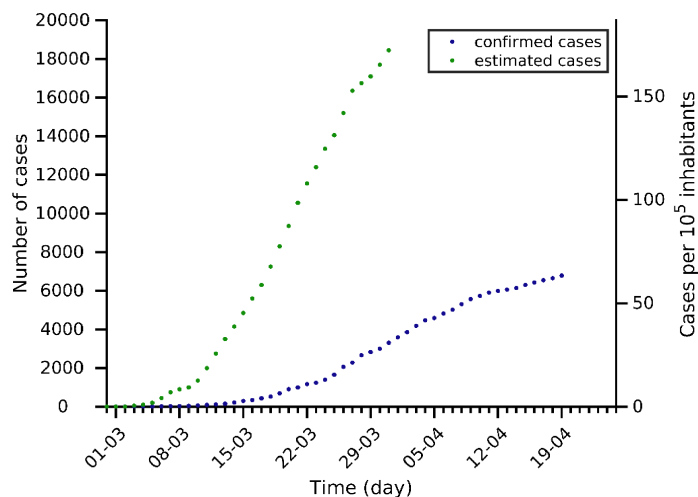
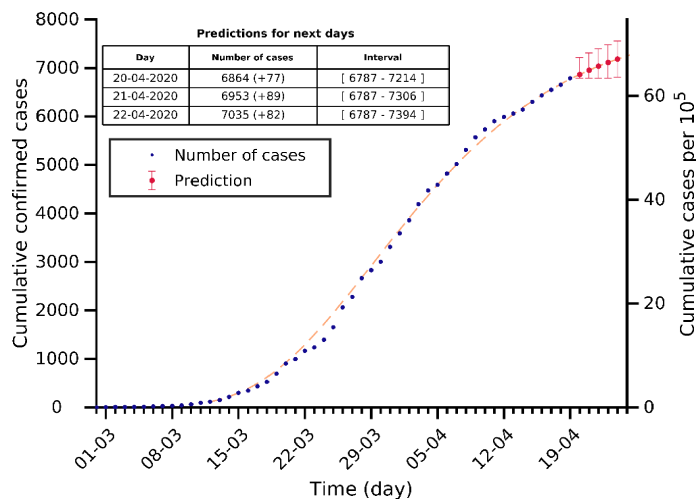
Denmark 19-04-2020. Population: 5.8M. Current cumulated incidence: 127/10⁵



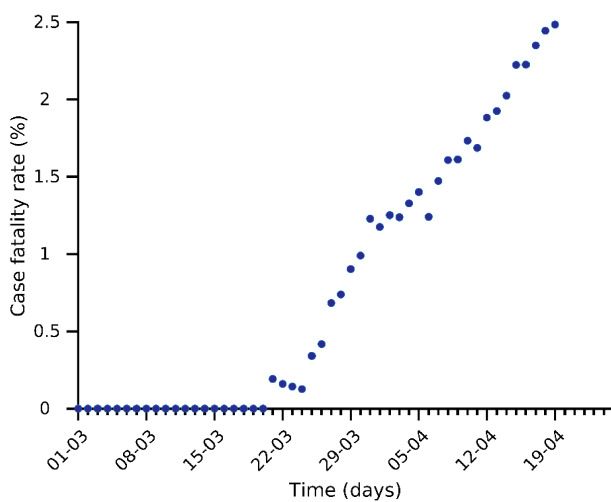
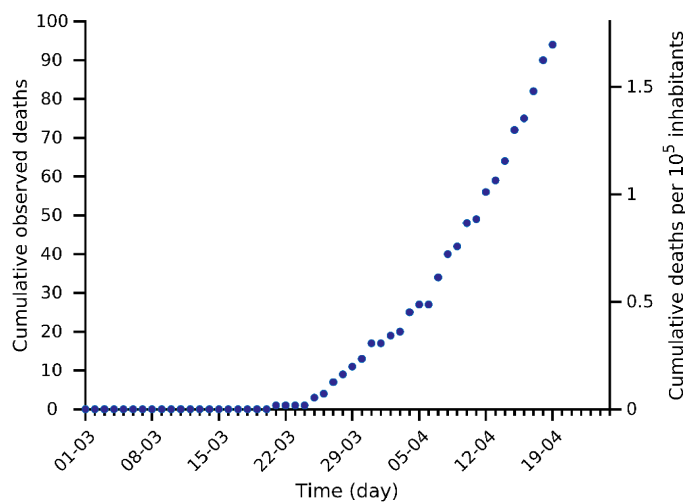
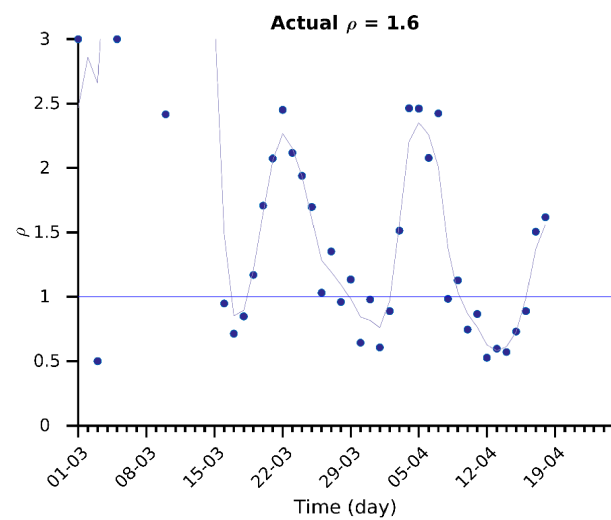
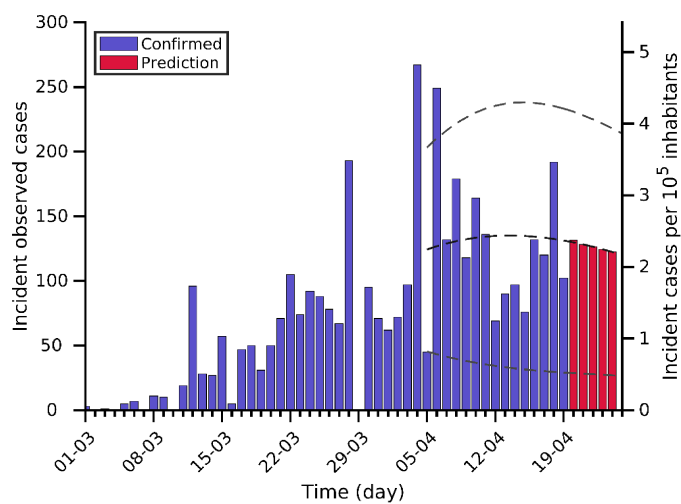
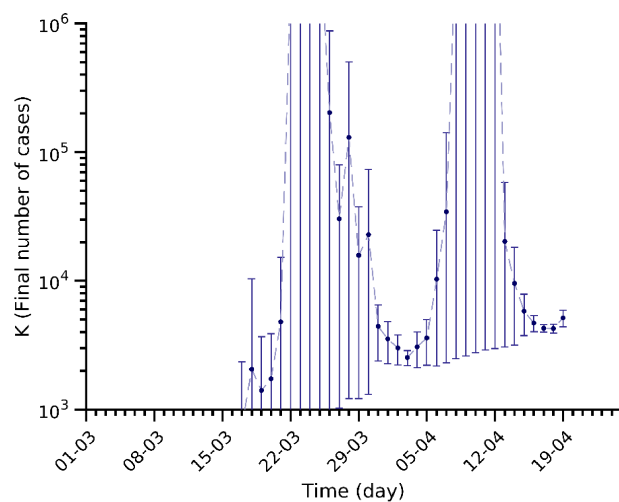
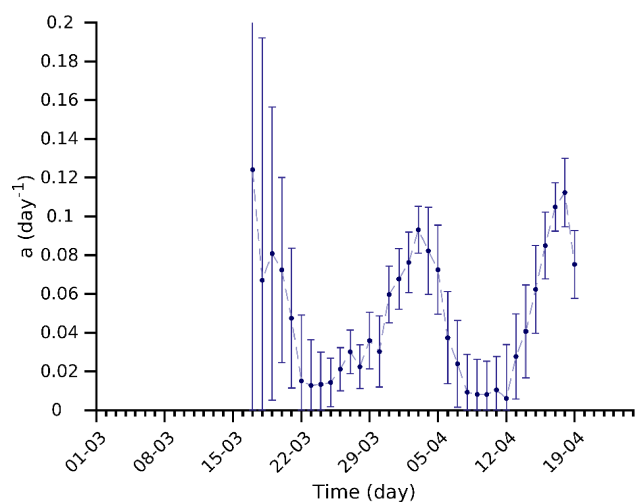
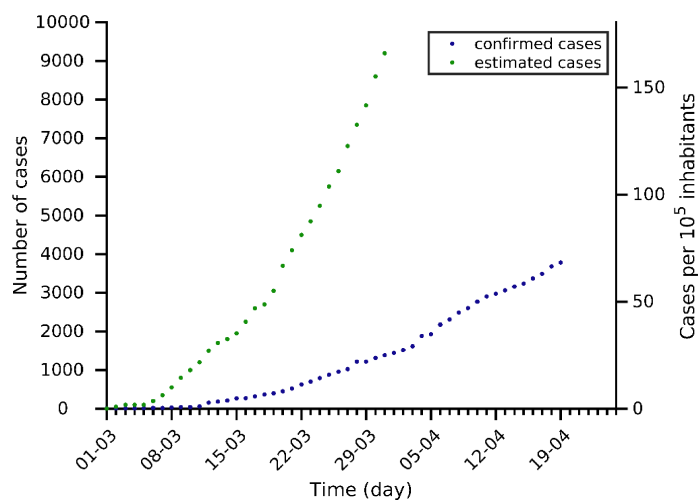
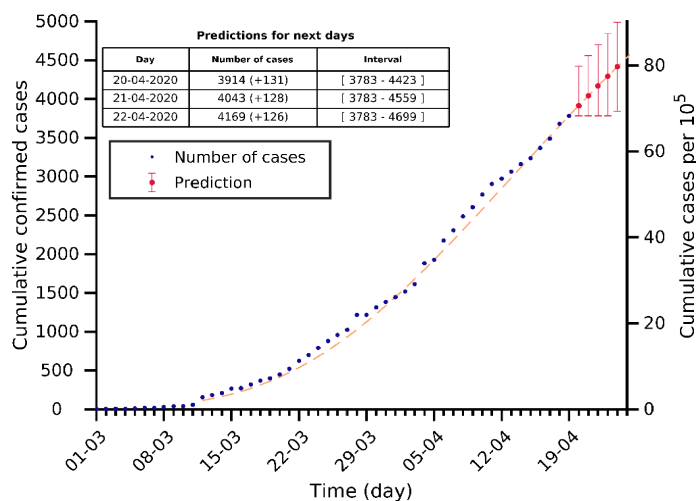
Norway 19-04-2020. Population: 5.4M. Current cumulated incidence: 130/10⁵



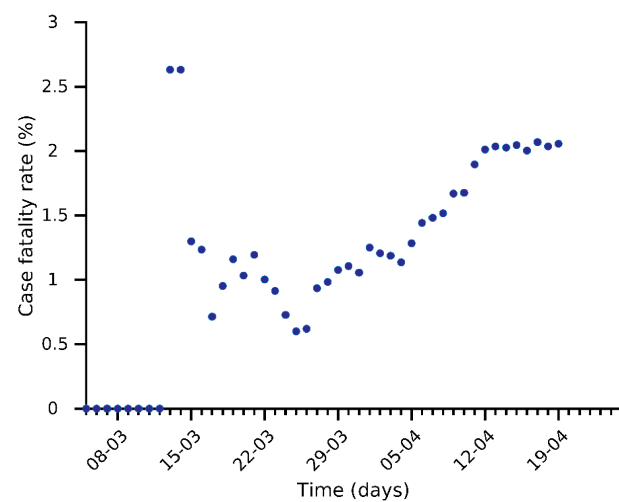
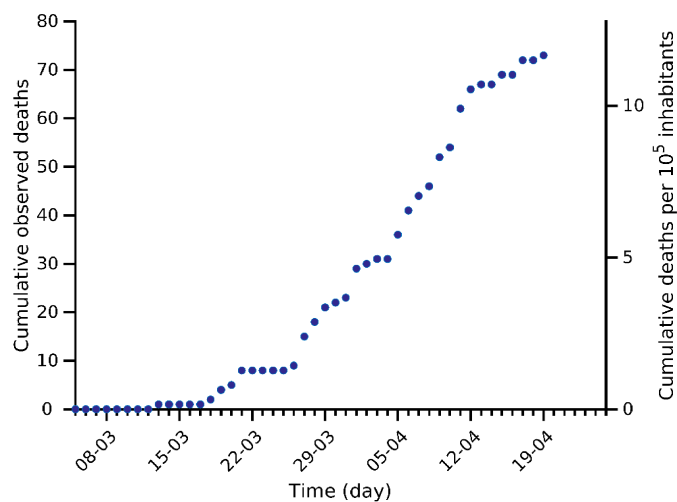
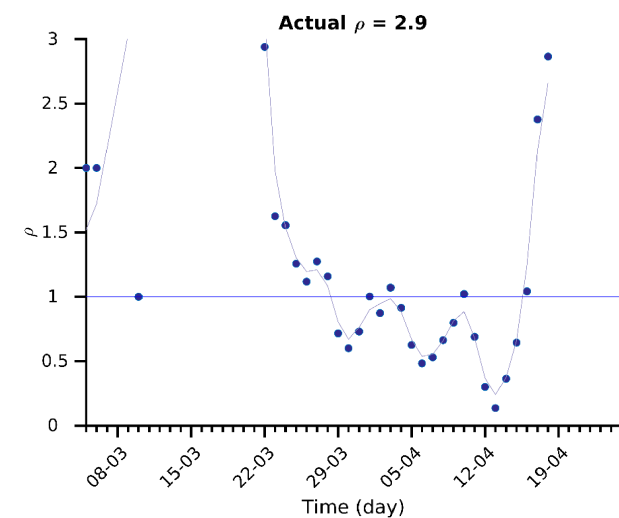
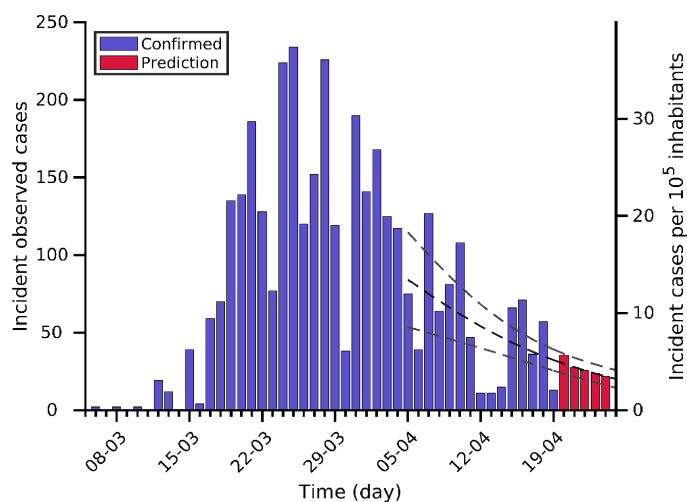
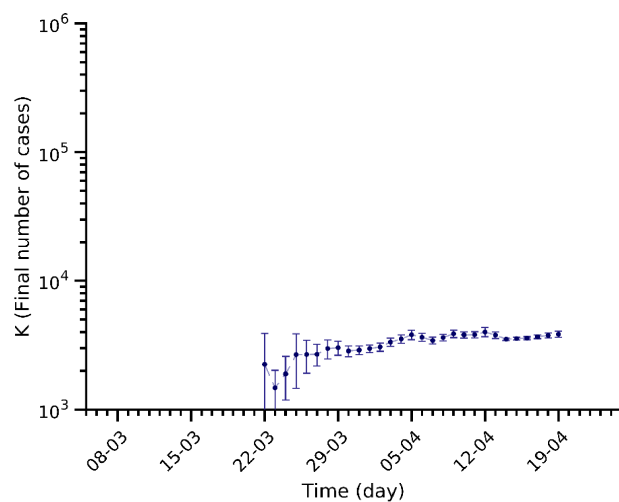
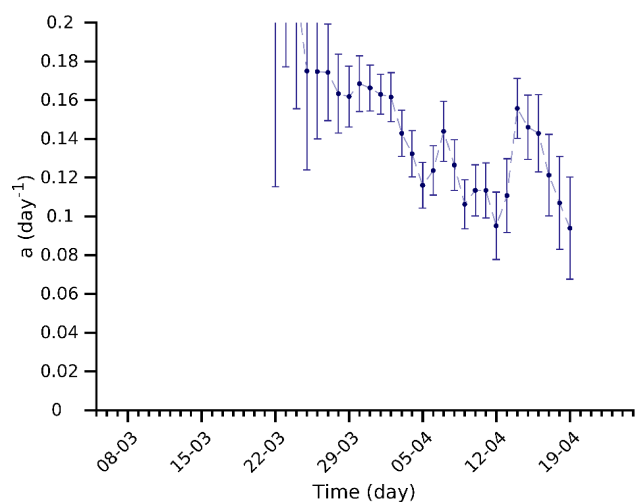
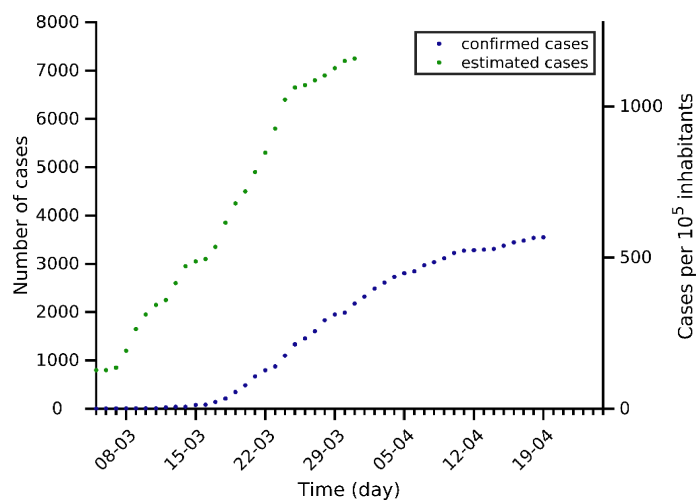
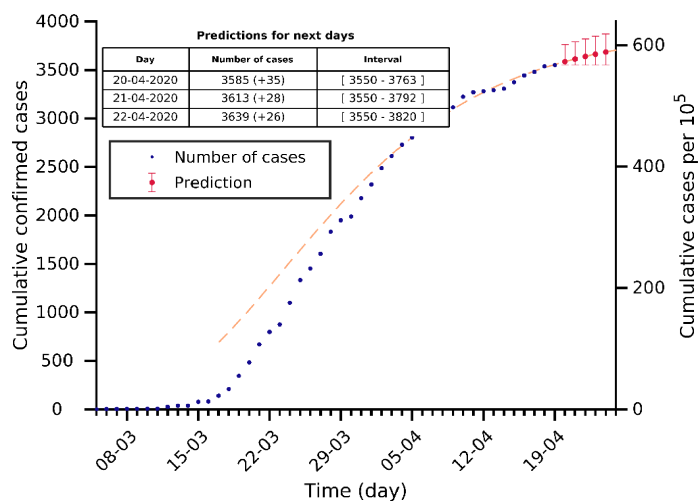
Czech Rep 19-04-2020. Population: 10.7M. Current cumulated incidence: 63/10⁵



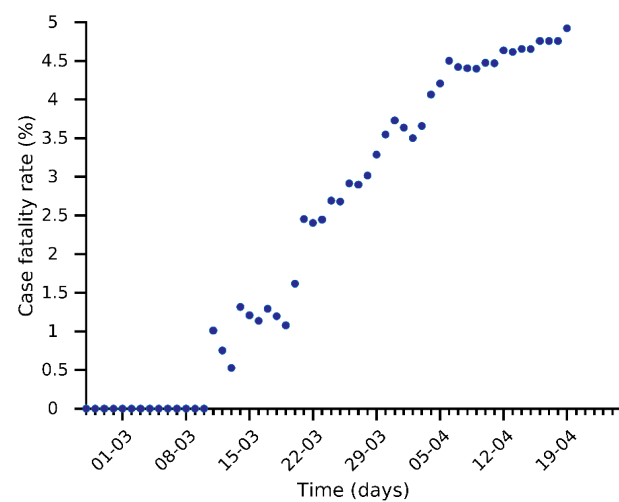
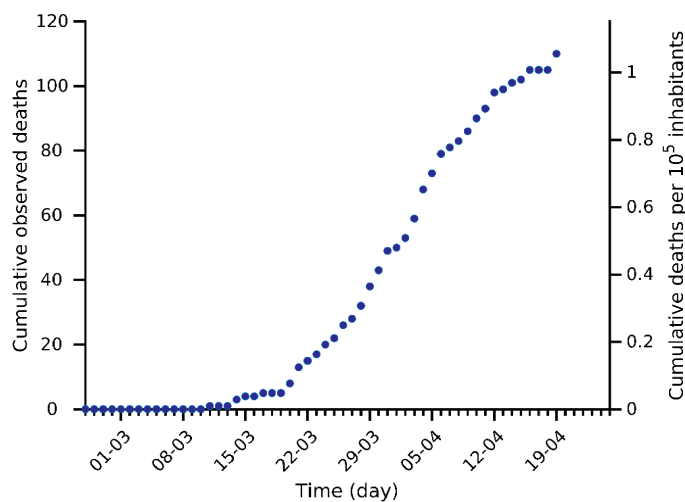
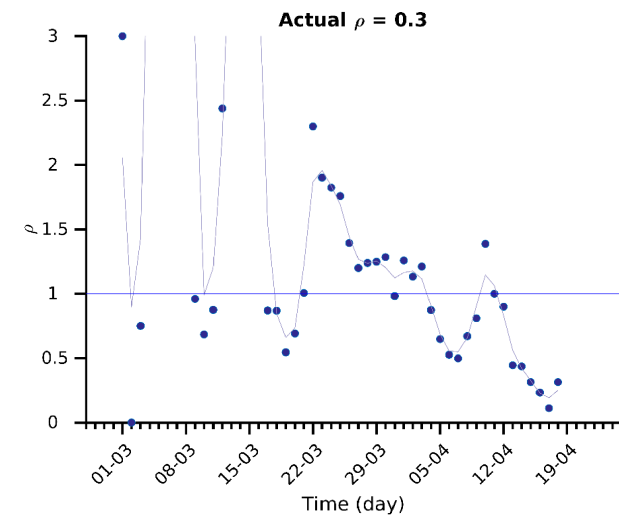
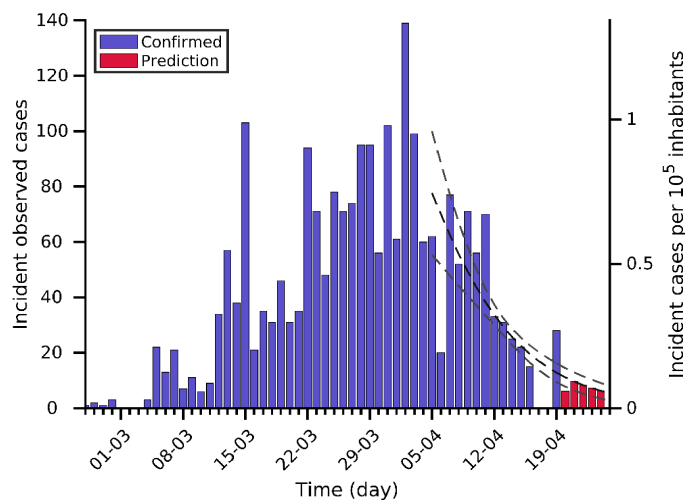
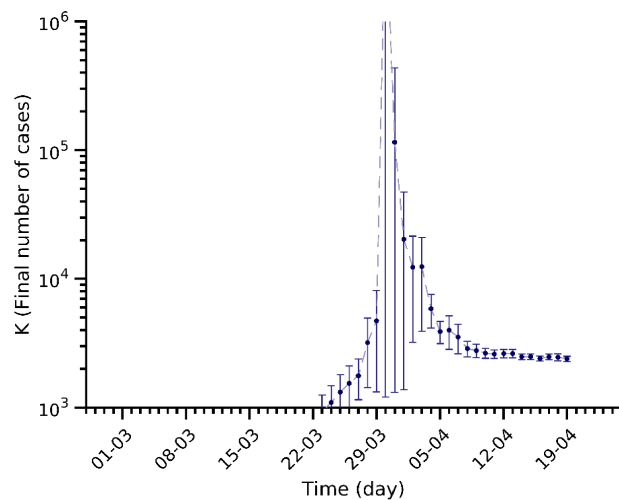
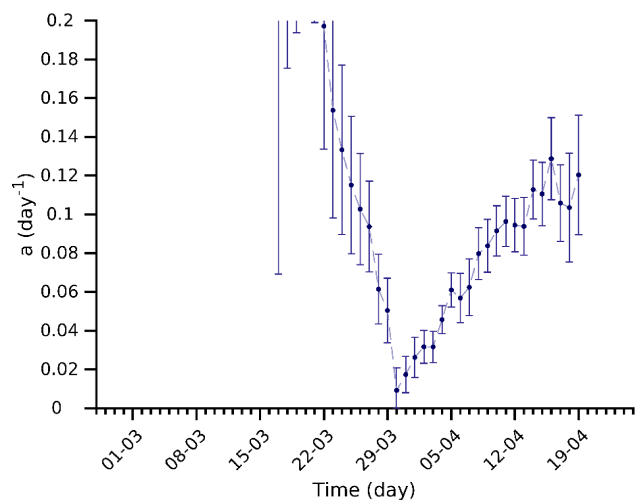
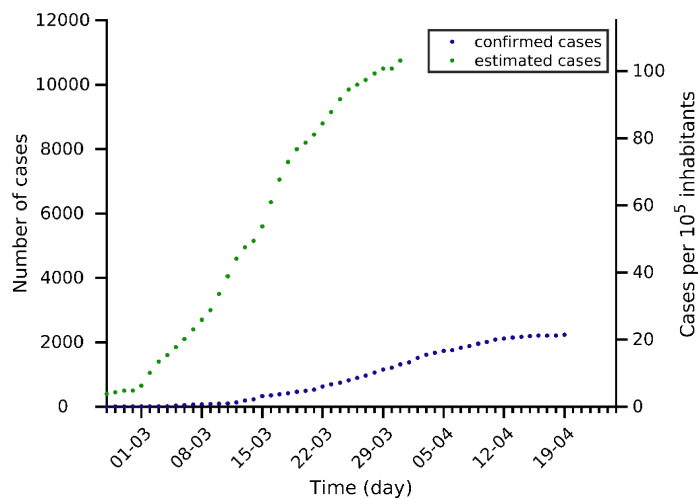
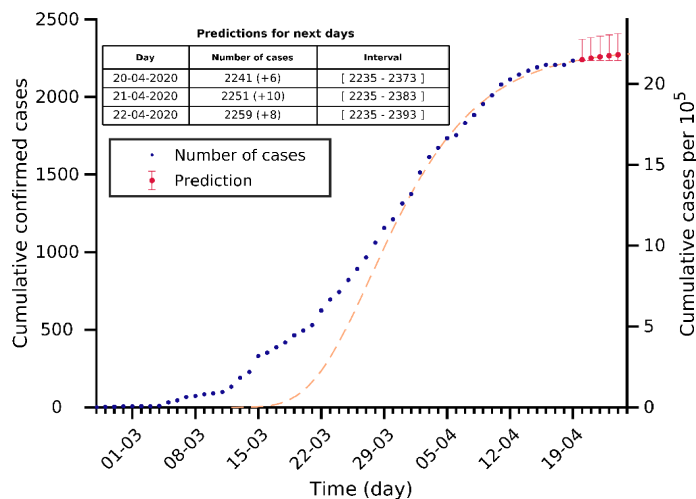
Finland 19-04-2020. Population: 5.5M. Current cumulated incidence: 68/10⁵



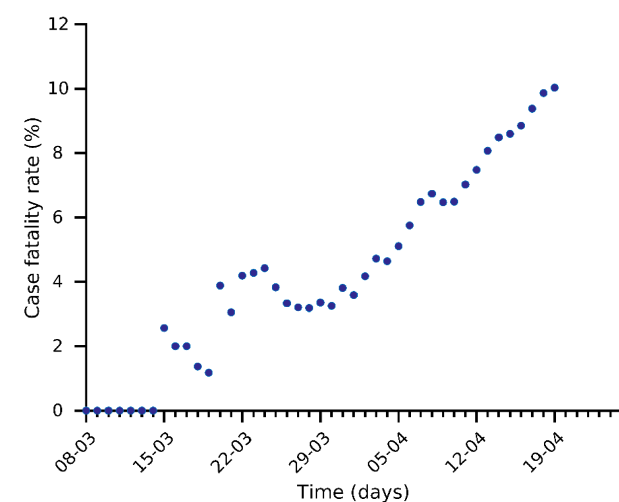
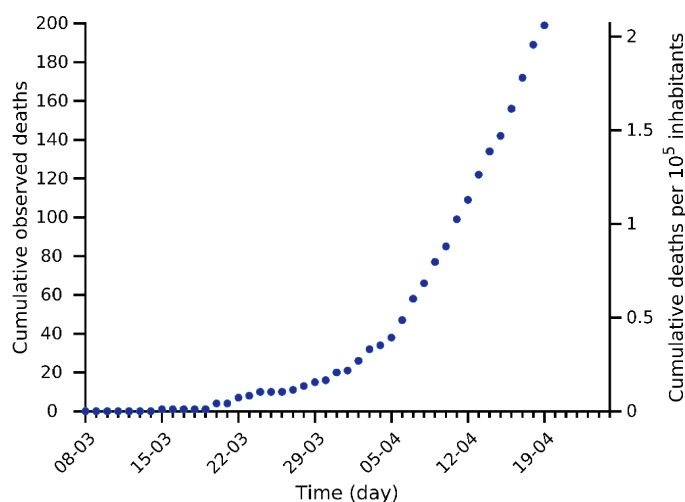
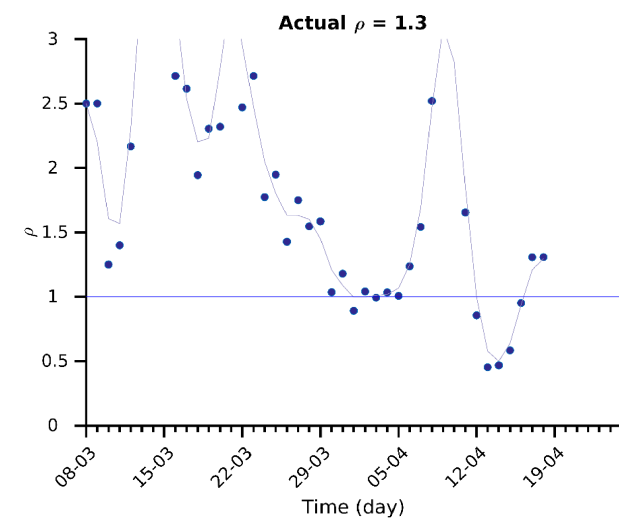
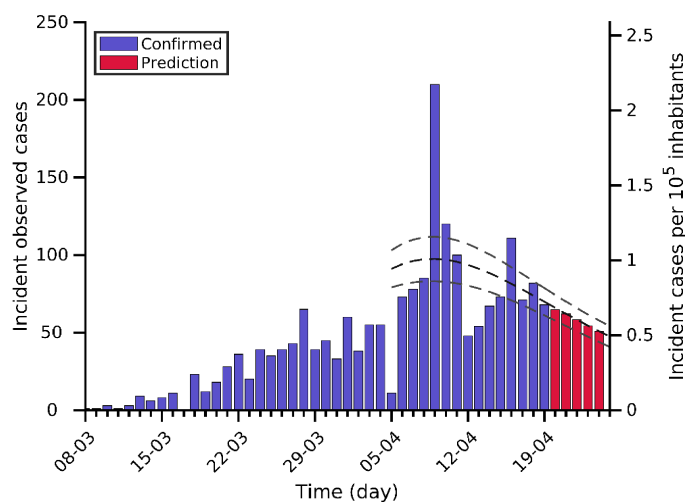
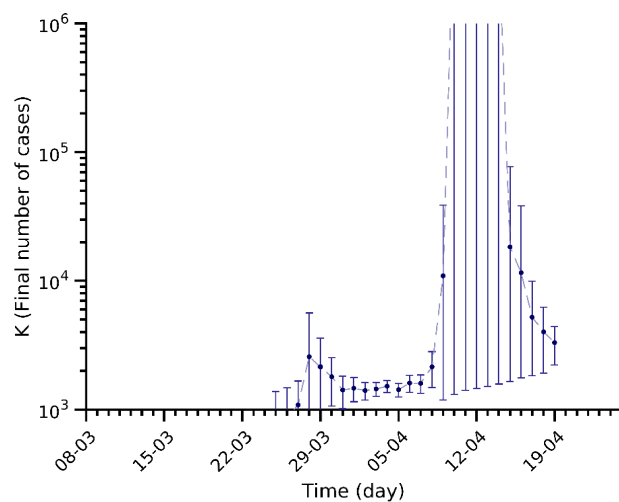
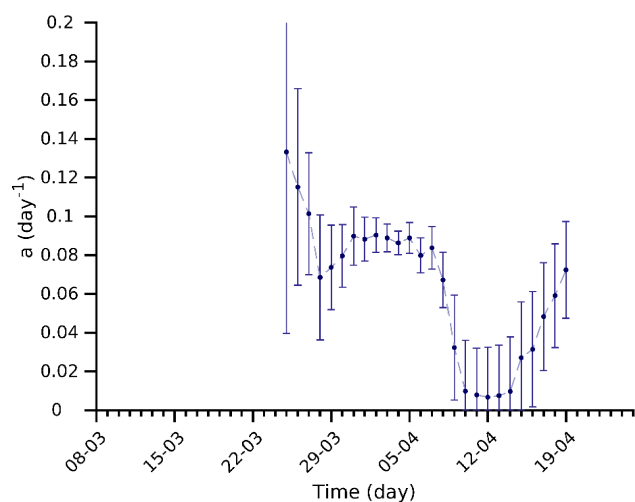
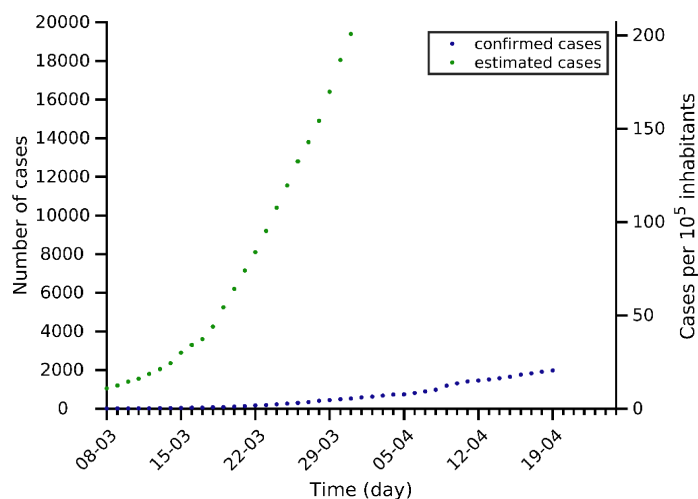
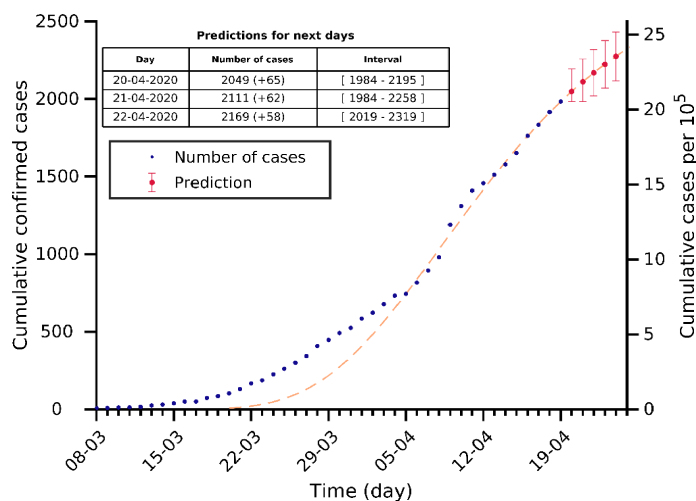
Luxembourg 19-04-2020. Population: 0.6M. Current cumulated incidence: 567/10⁵



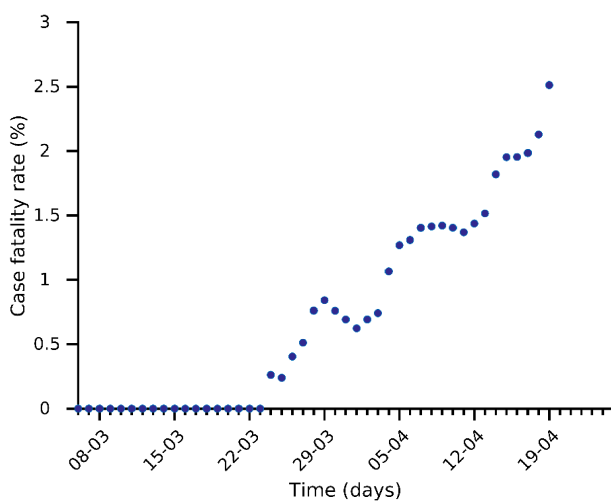
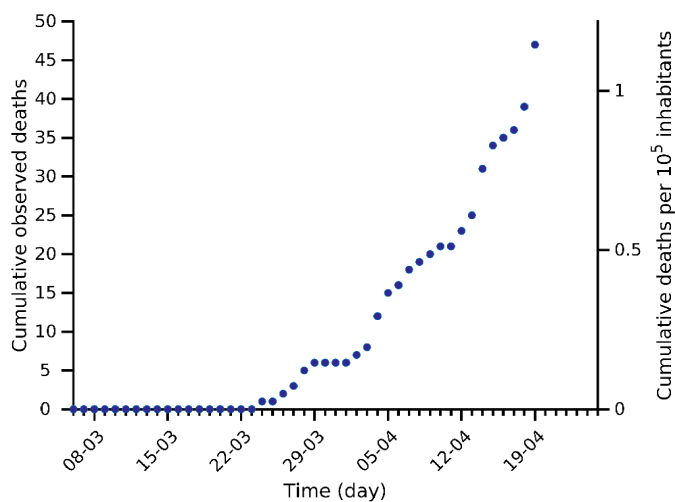
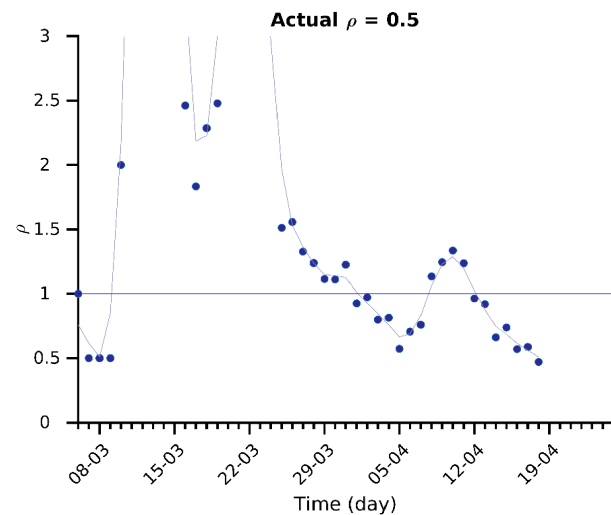
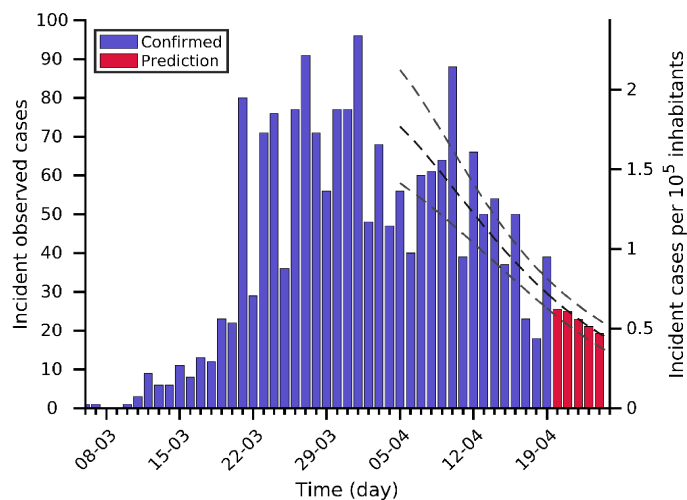
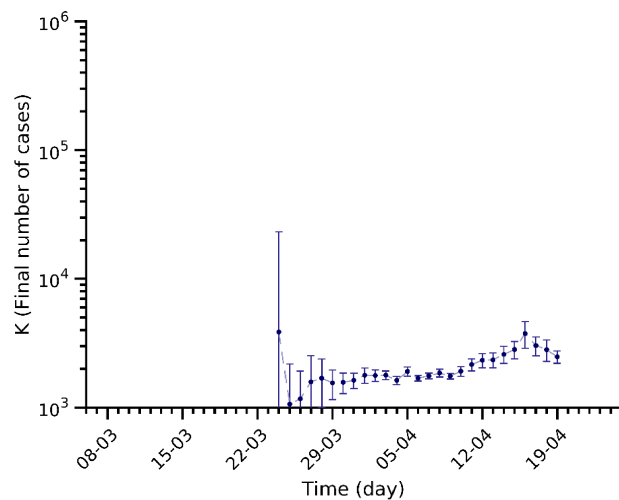
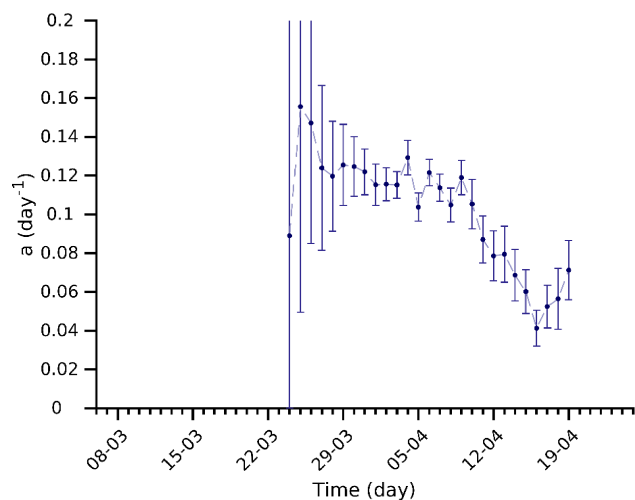
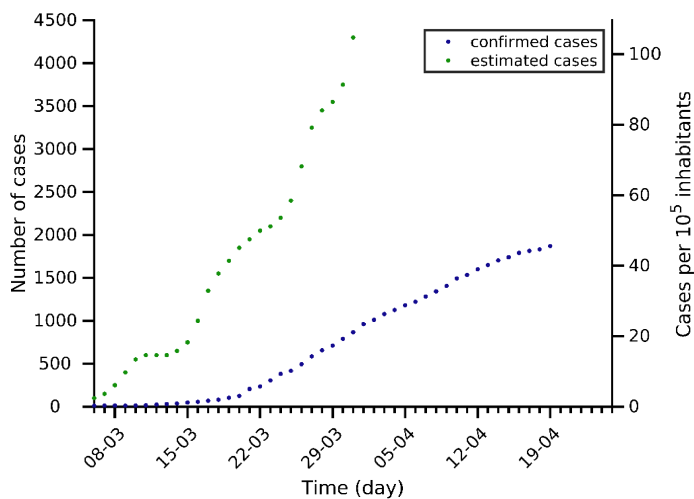
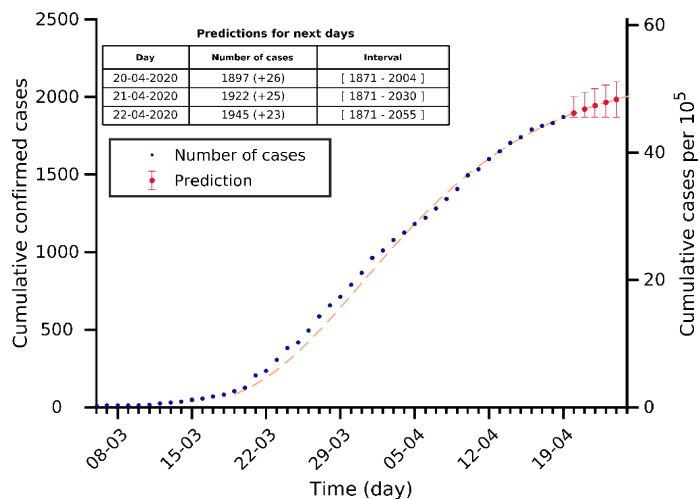
Greece 19-04-2020. Population: 10.4M. Current cumulated incidence: 21/10⁵



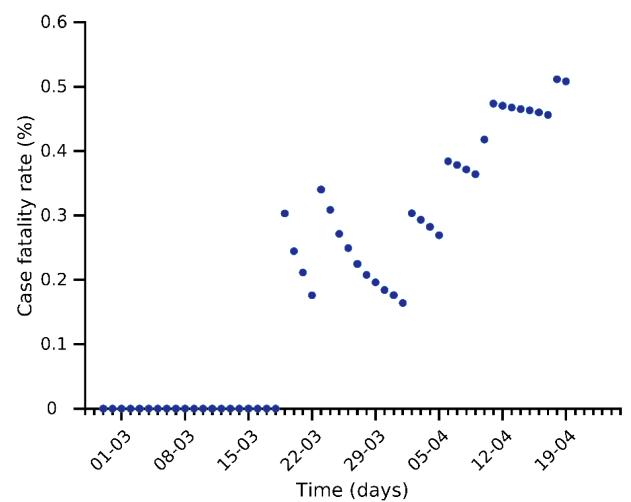
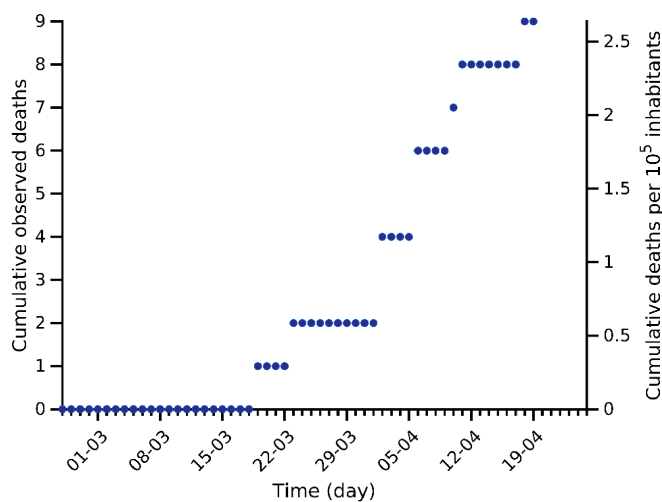
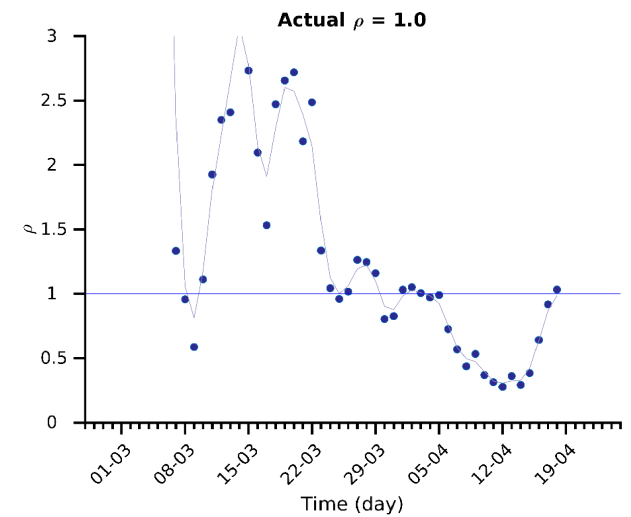
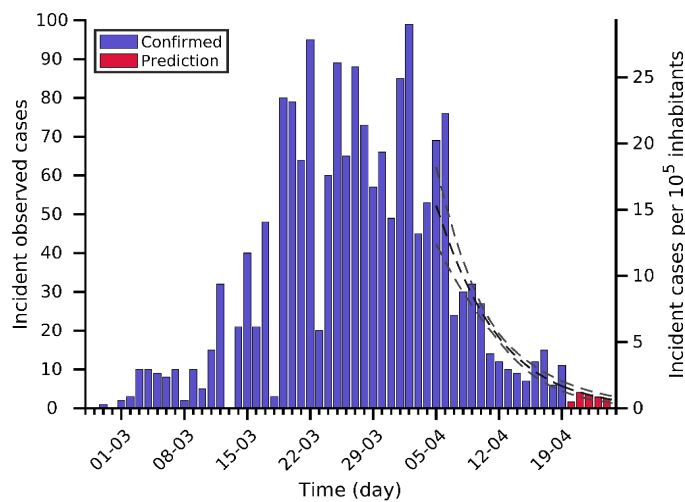
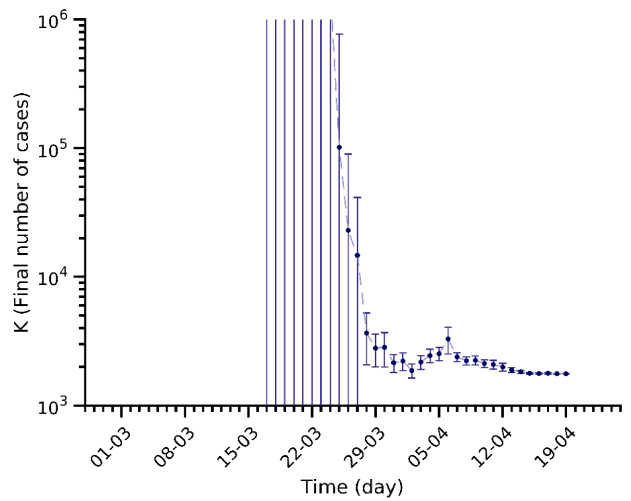
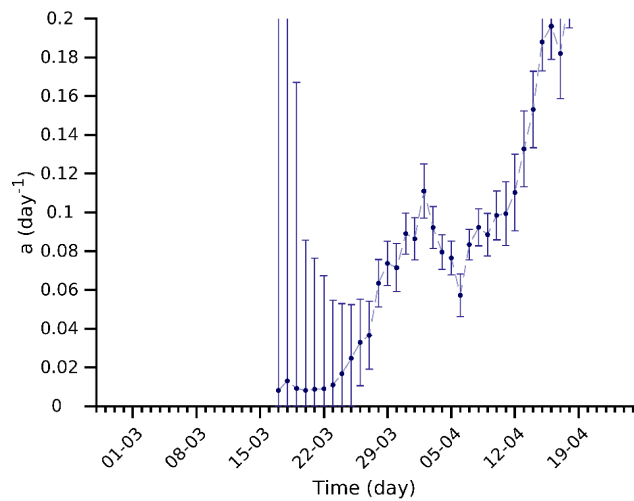
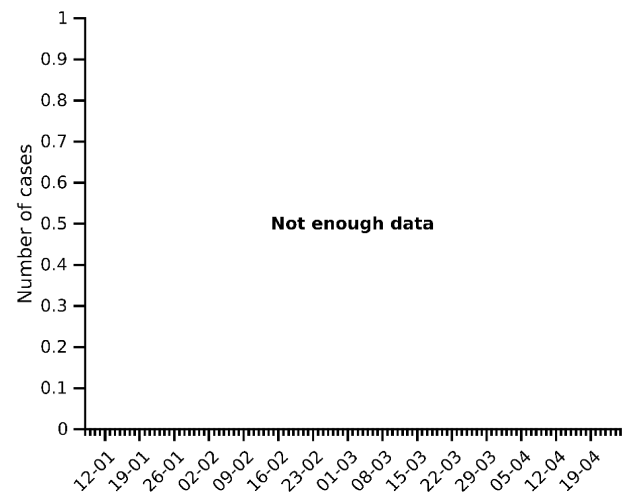
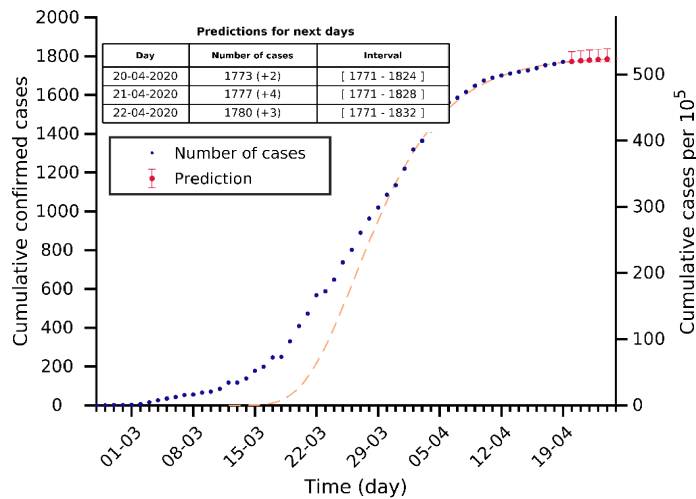
Hungary 19-04-2020. Population: 9.7M. Current cumulated incidence: 21/10⁵



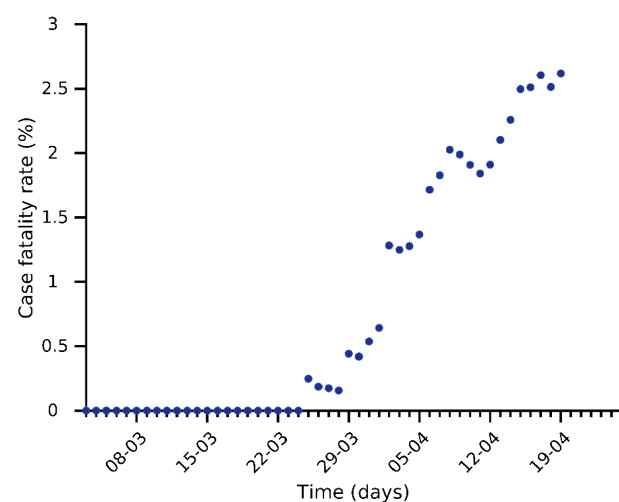
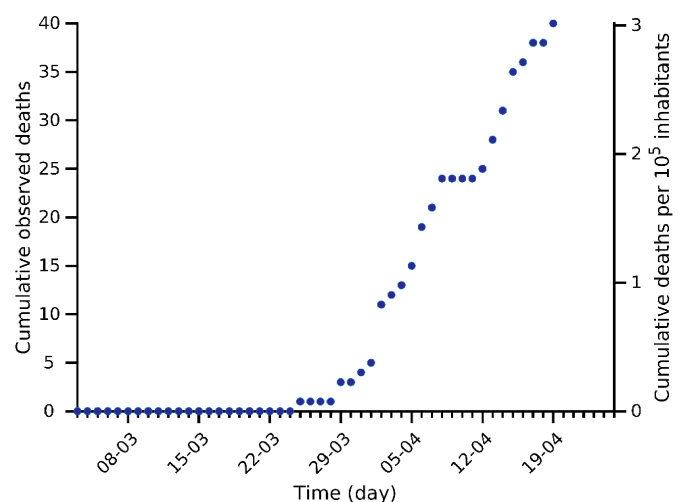
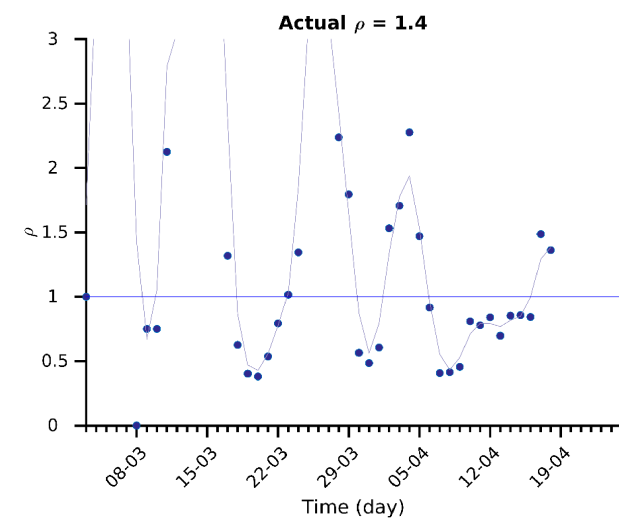
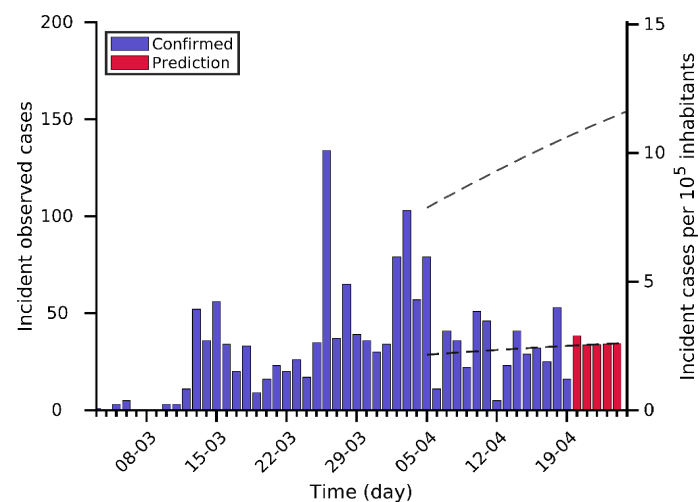
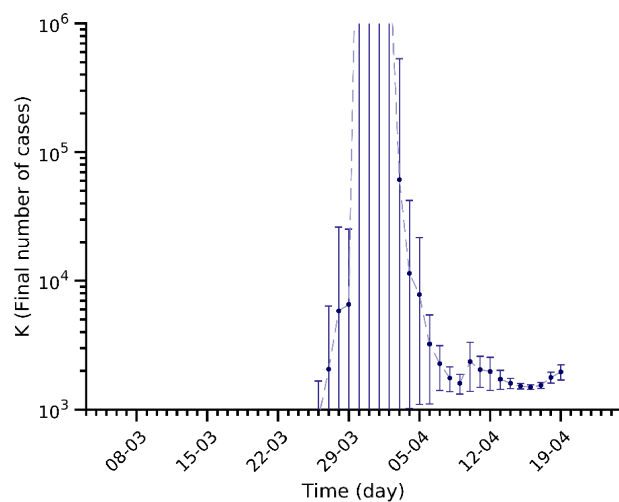
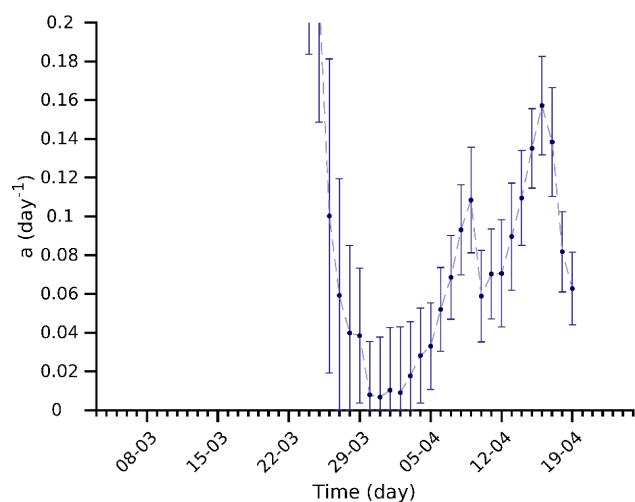
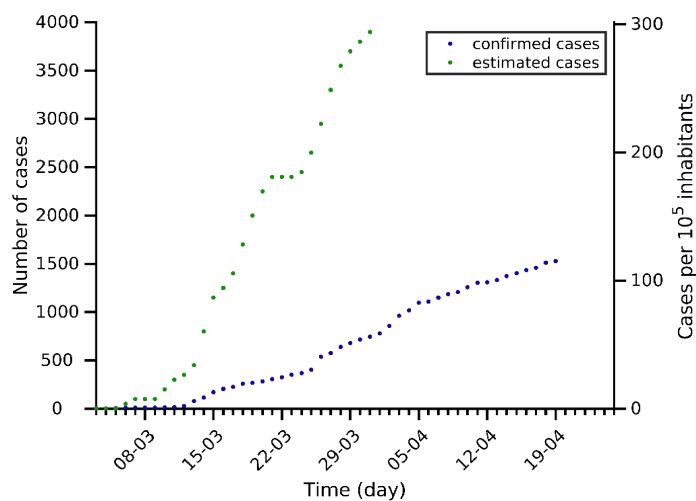
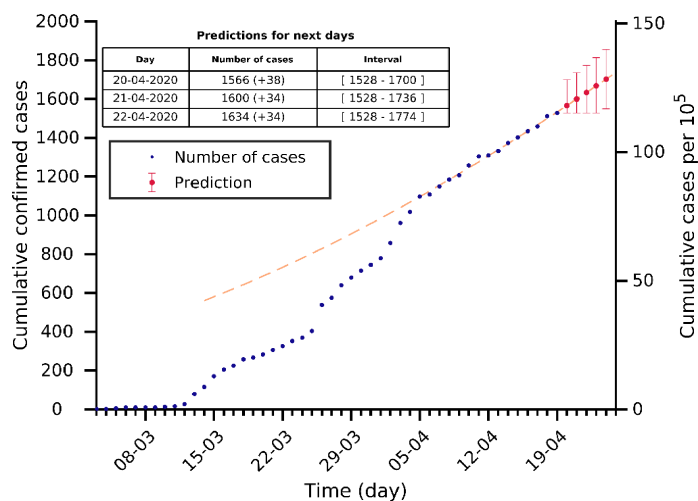
Croatia 19-04-2020. Population: 4.1M. Current cumulated incidence: 46/10⁵



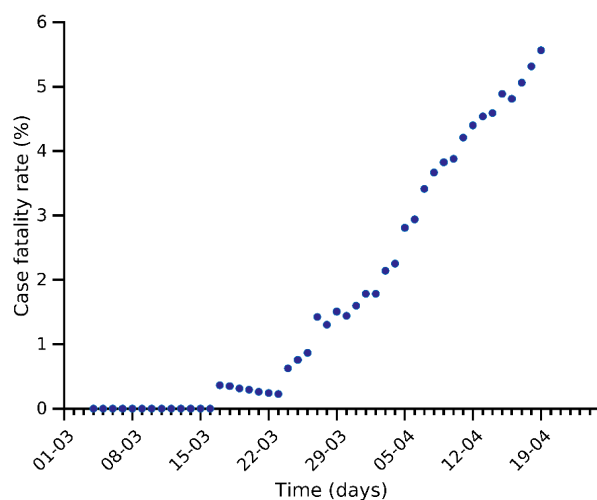
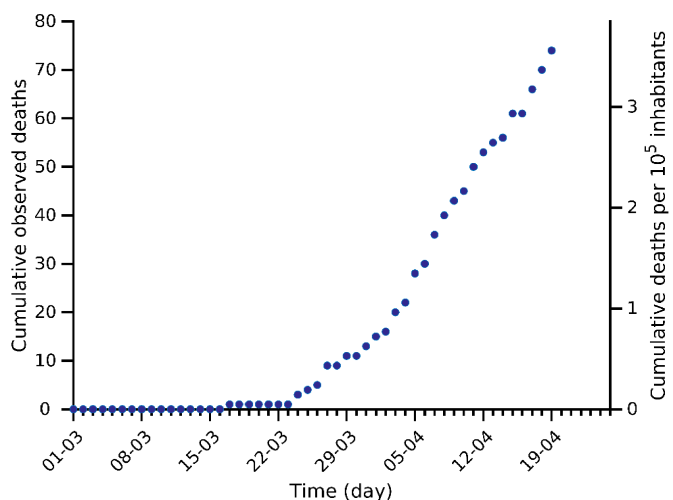
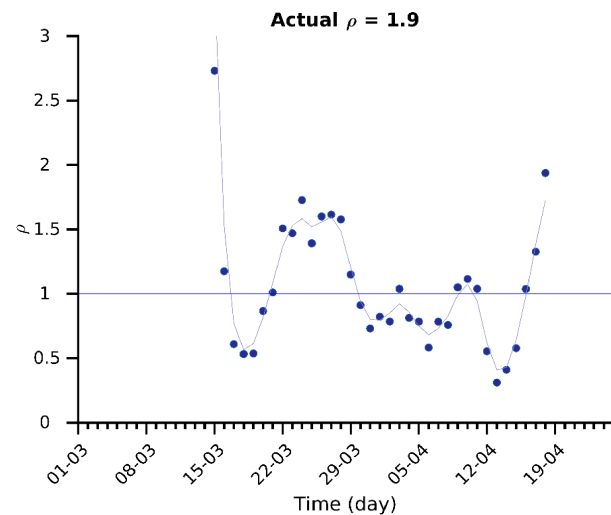
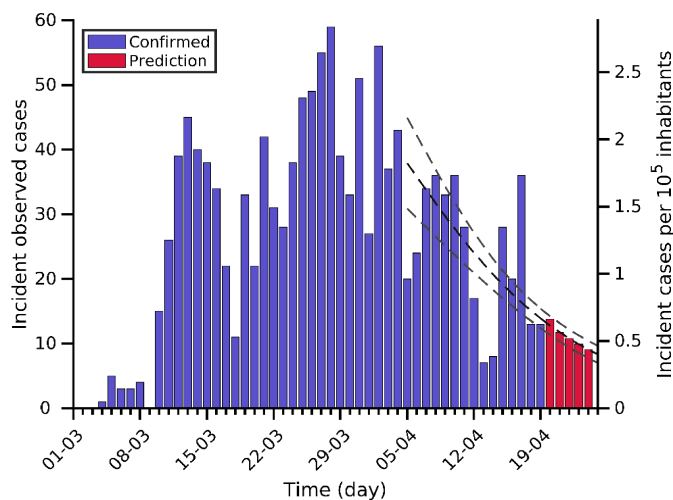
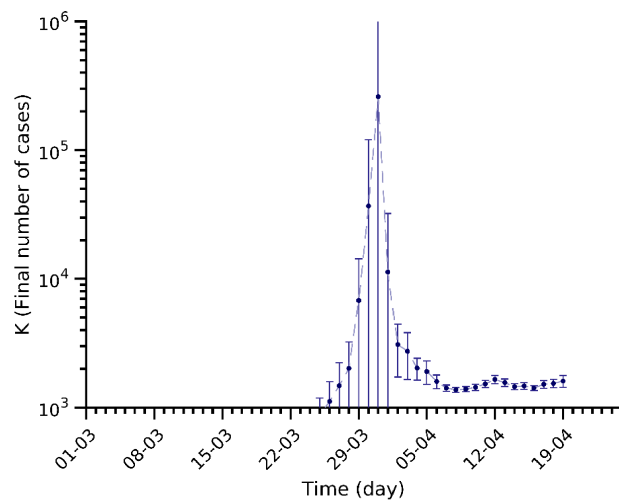
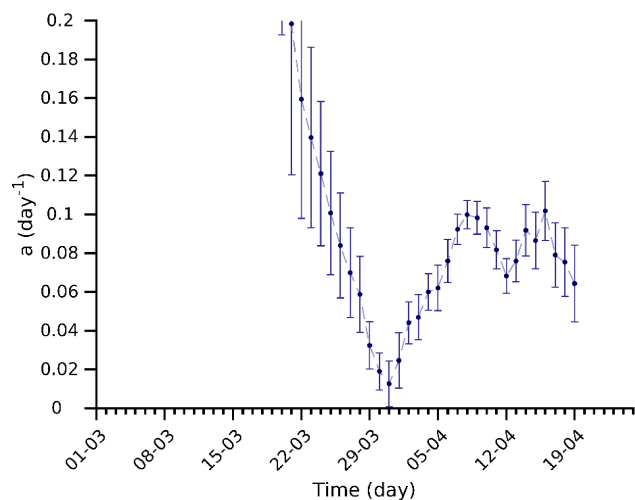
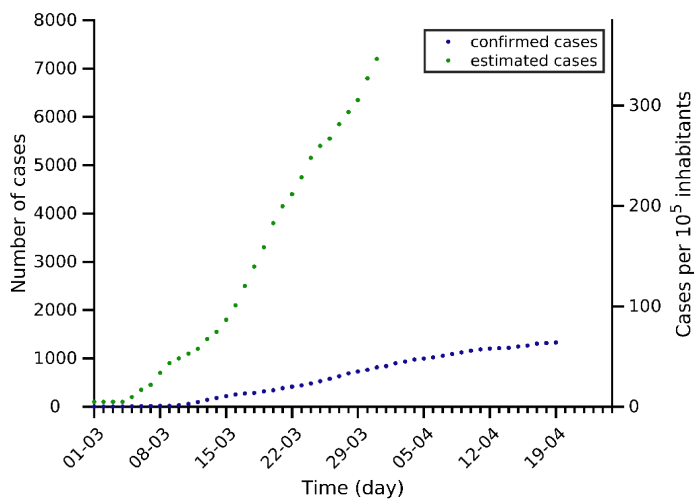
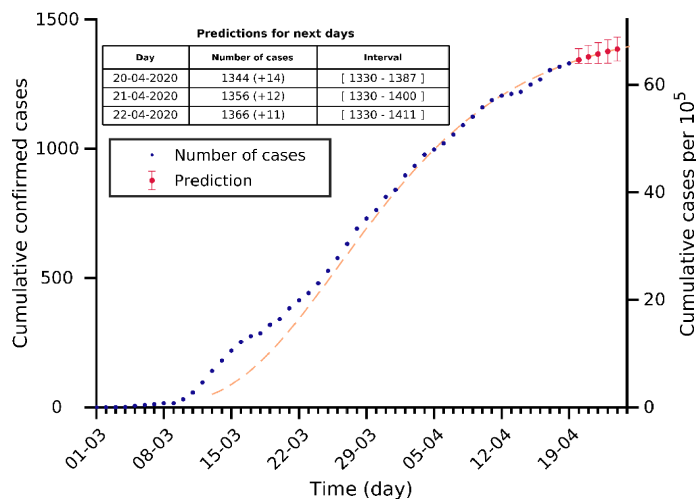
Iceland 19-04-2020. Population: 0.3M. Current cumulated incidence: 519/10⁵



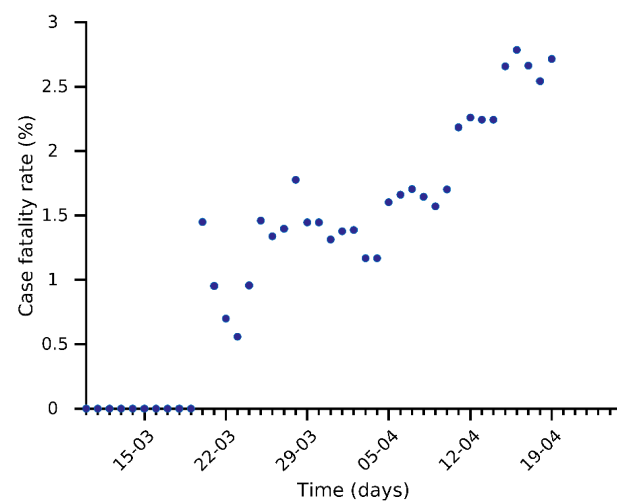
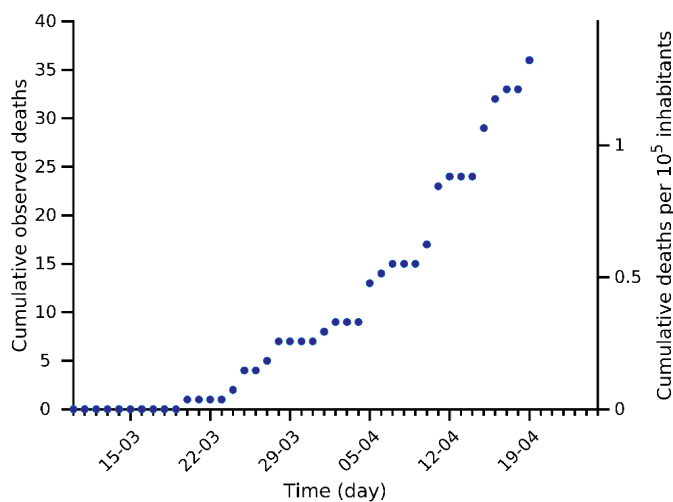
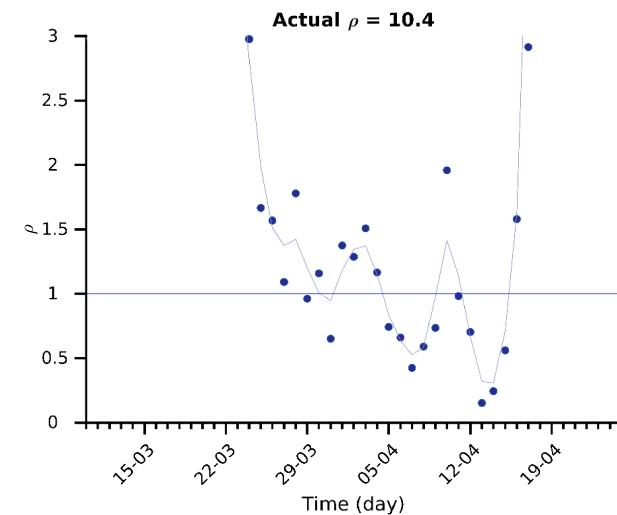
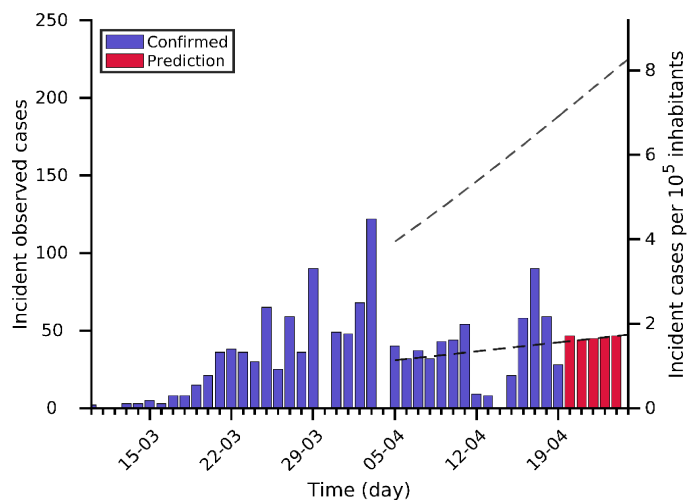
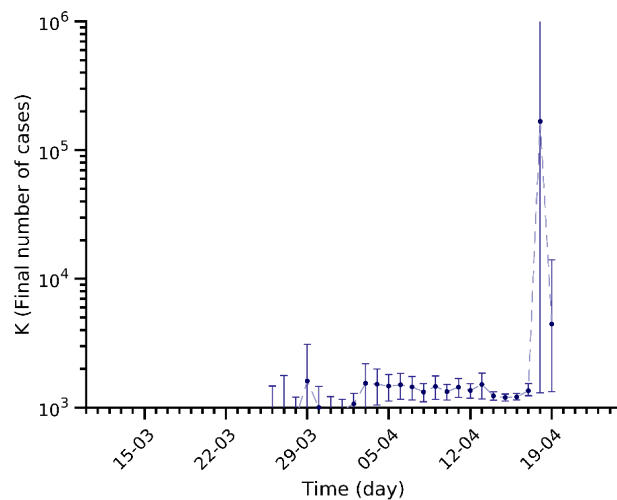
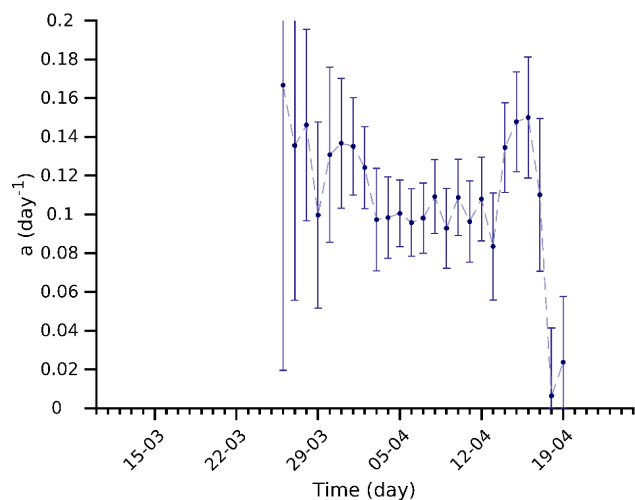
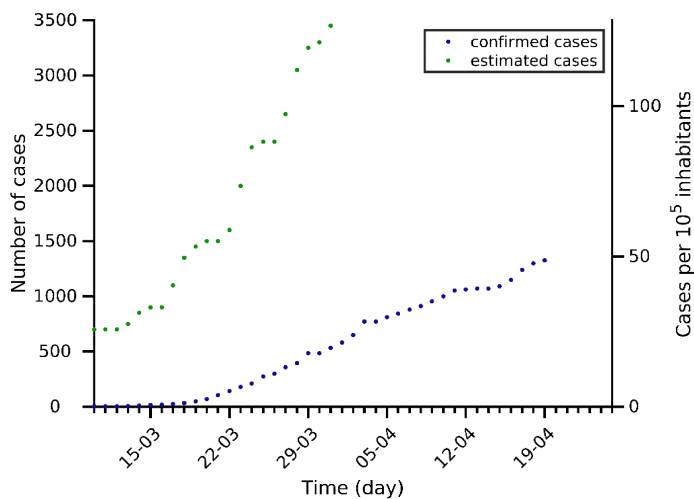
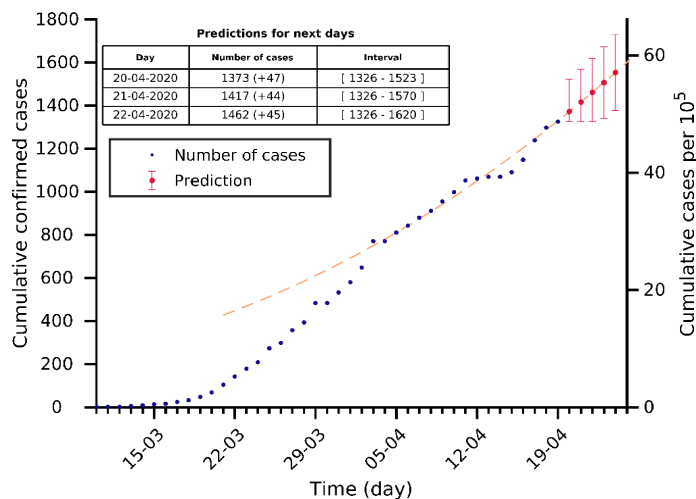
Estonia 19-04-2020. Population: 1.3M. Current cumulated incidence: 115/10⁵



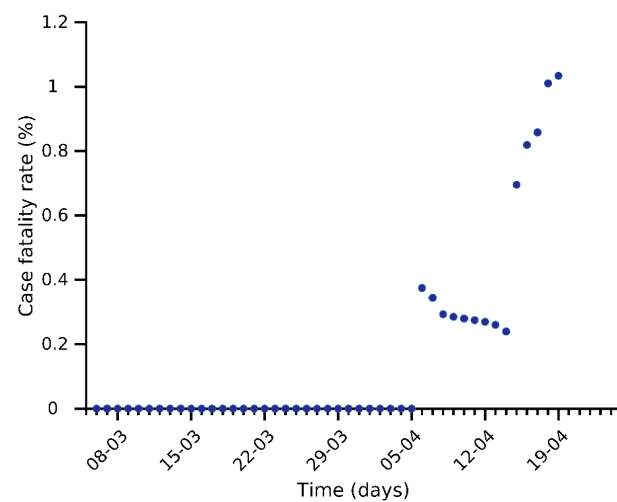
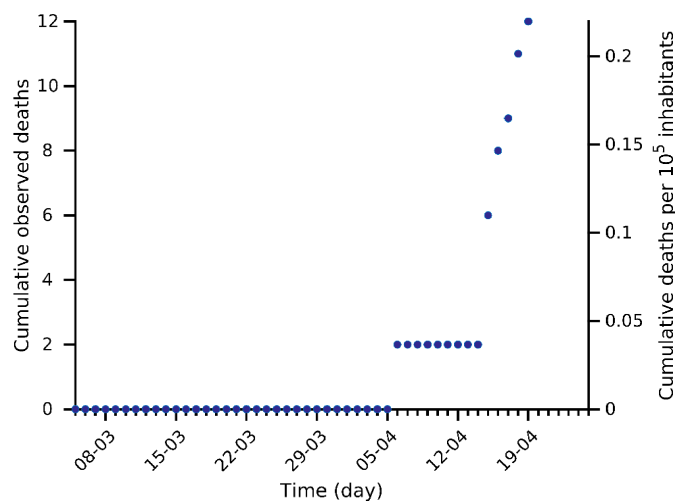
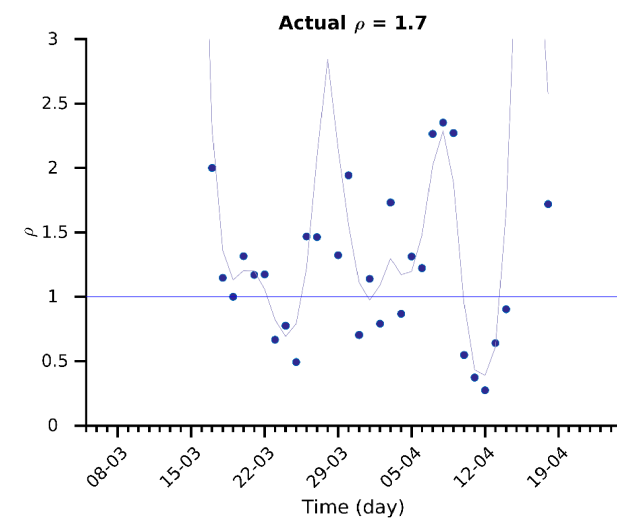
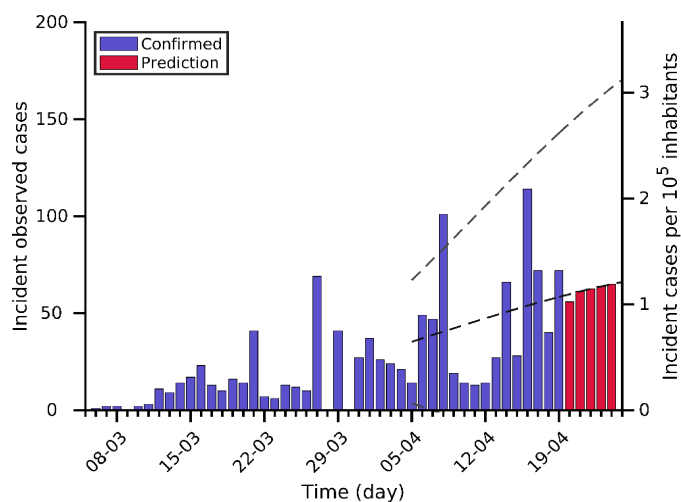
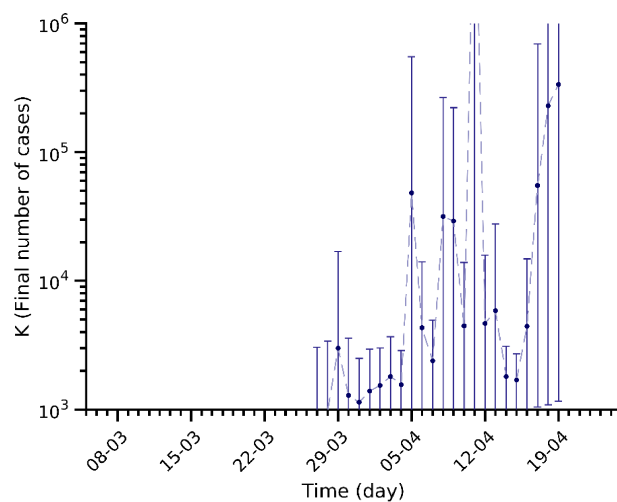
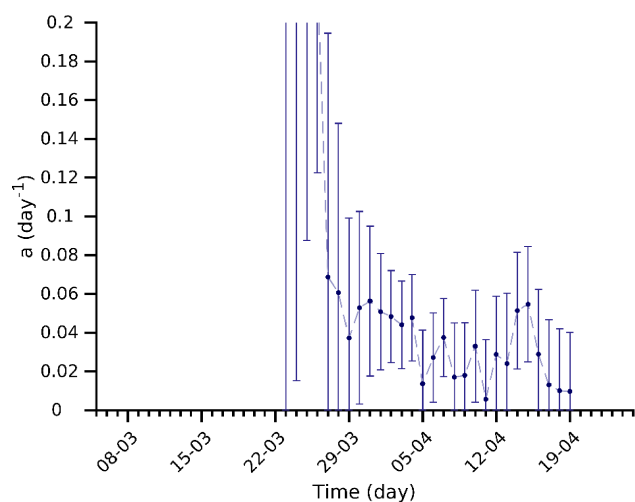
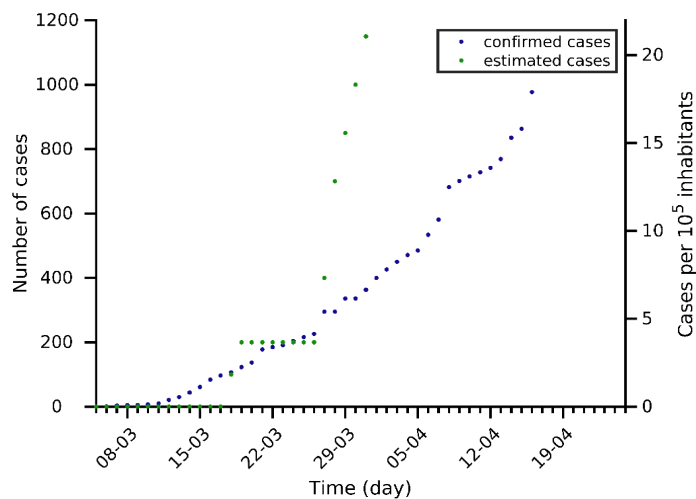
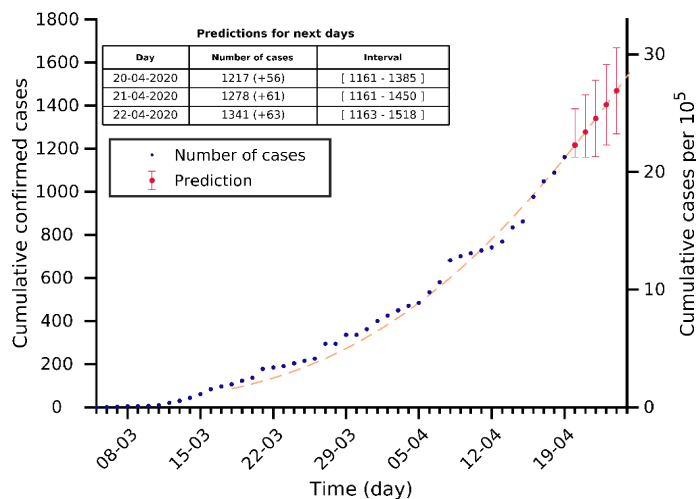
Slovenia 19-04-2020. Population: 2.1M. Current cumulated incidence: 64/10⁵



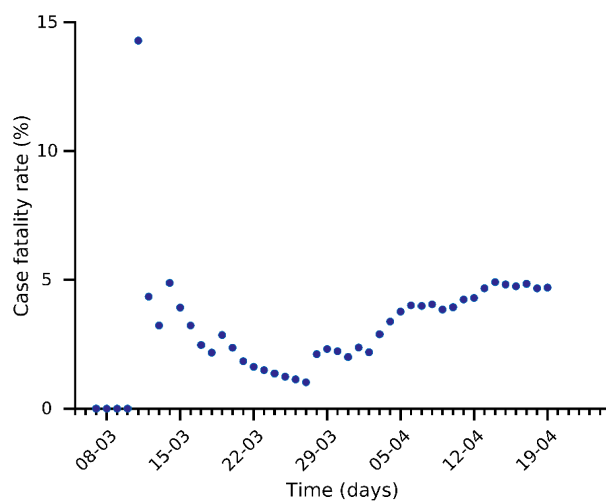
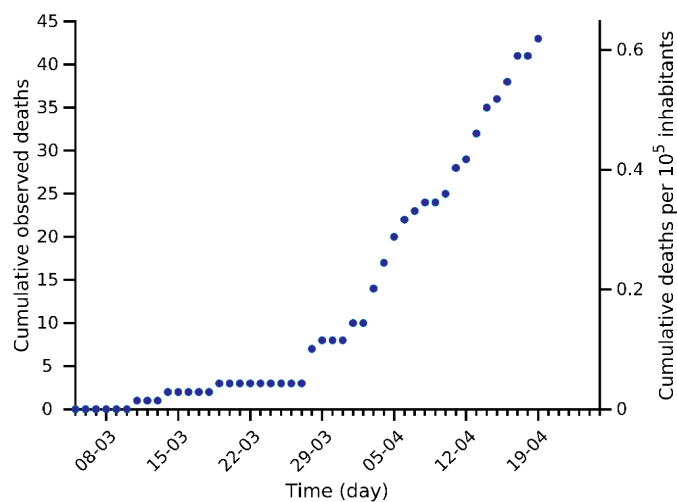
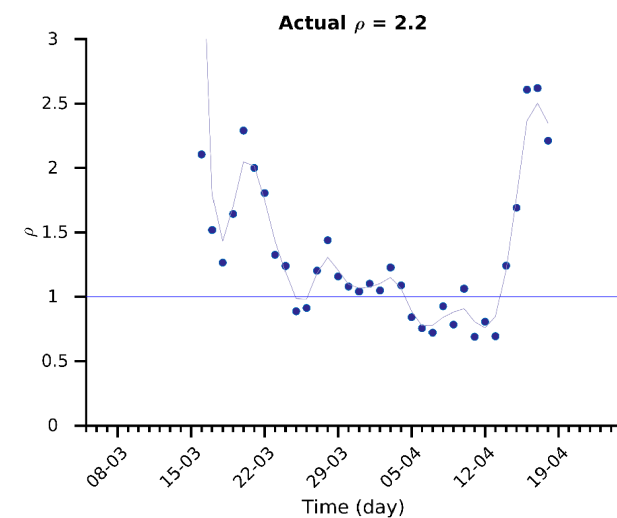
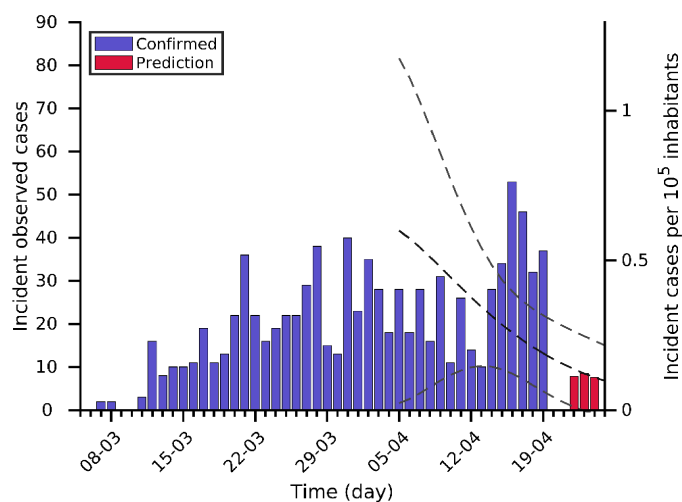
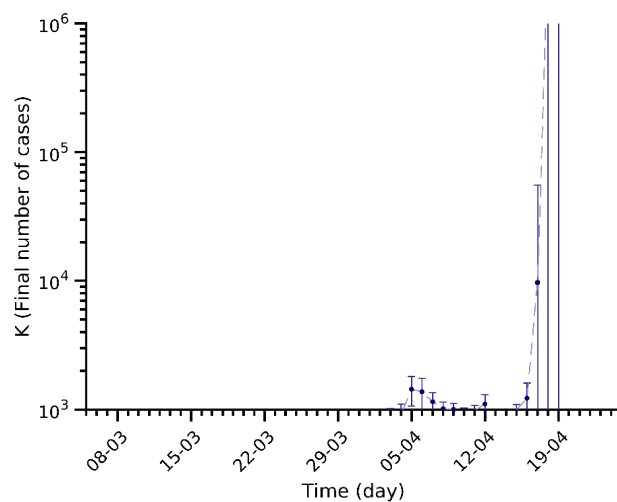
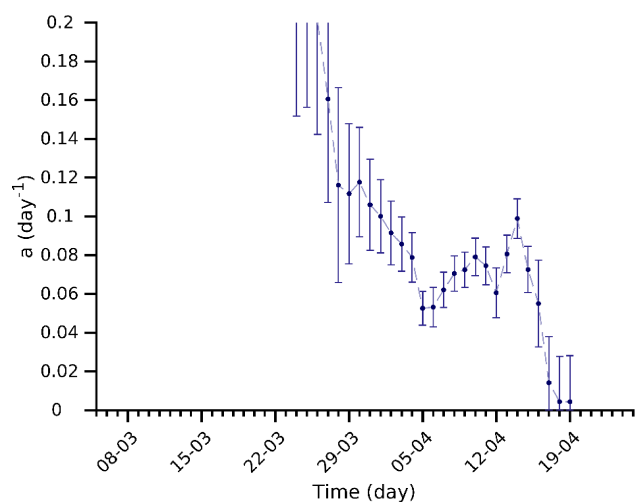
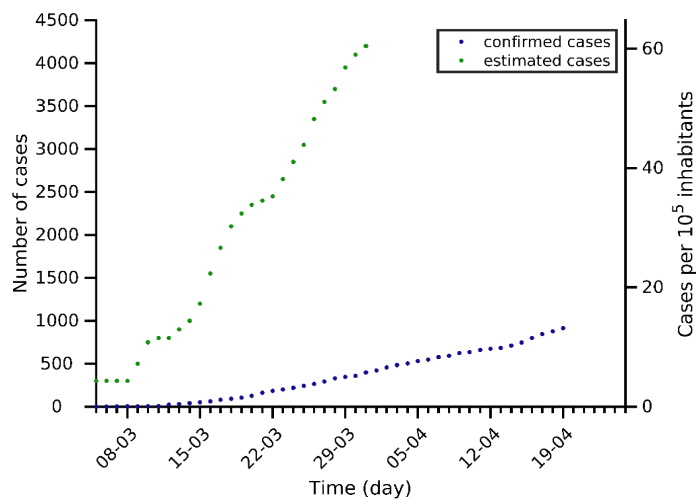
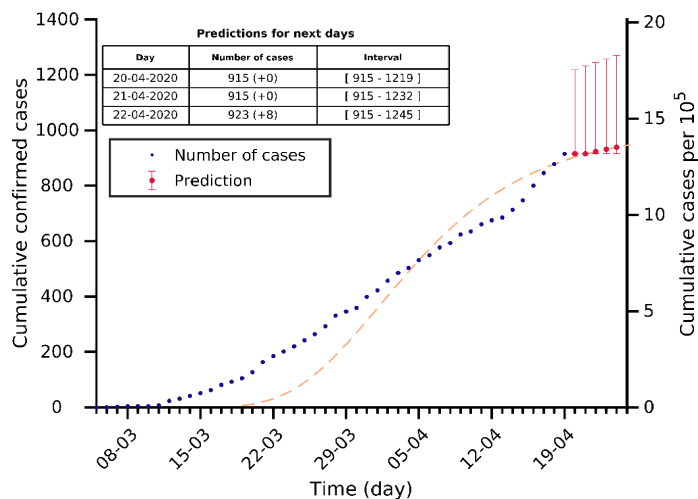
Lithuania 19-04-2020. Population: 2.7M. Current cumulated incidence: 49/10⁵



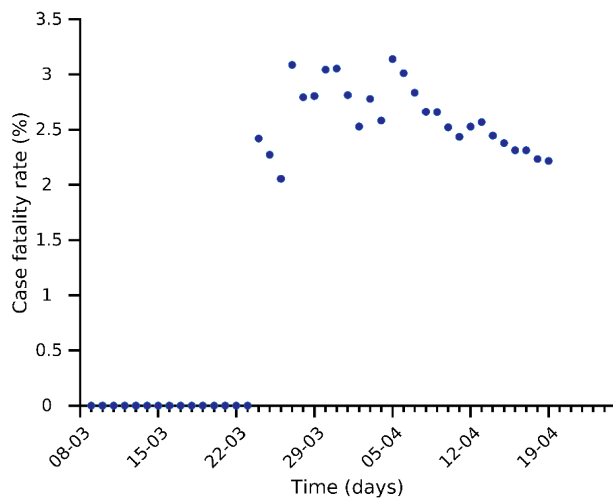
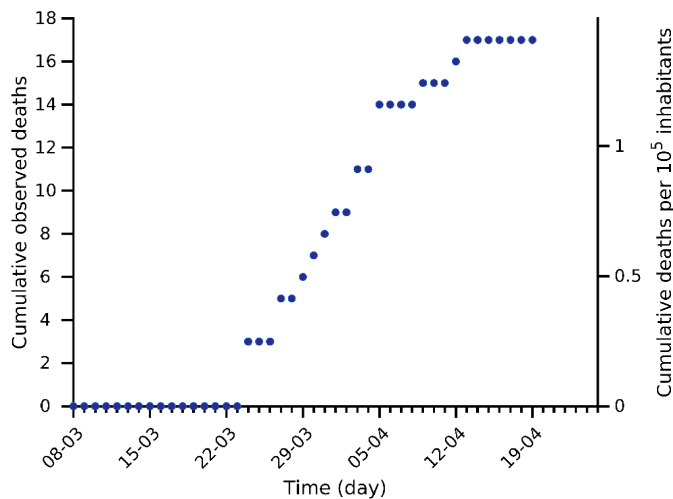
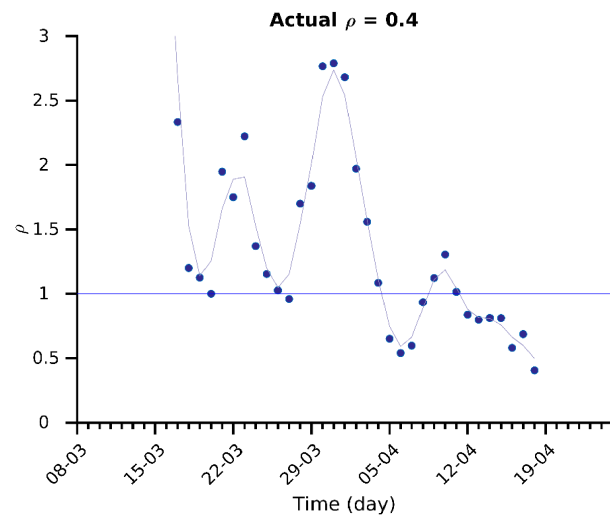
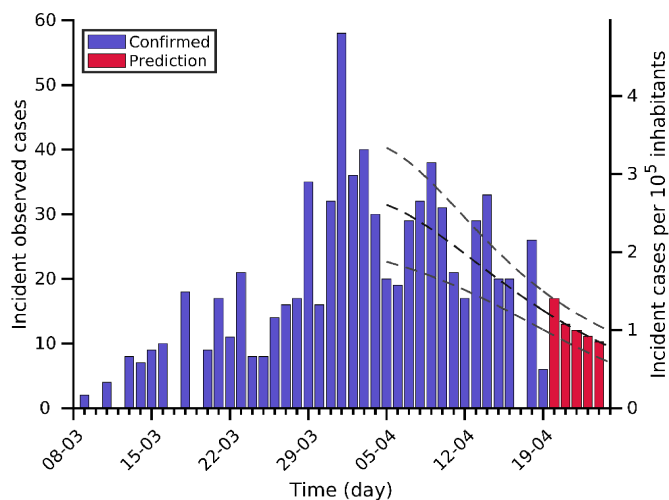
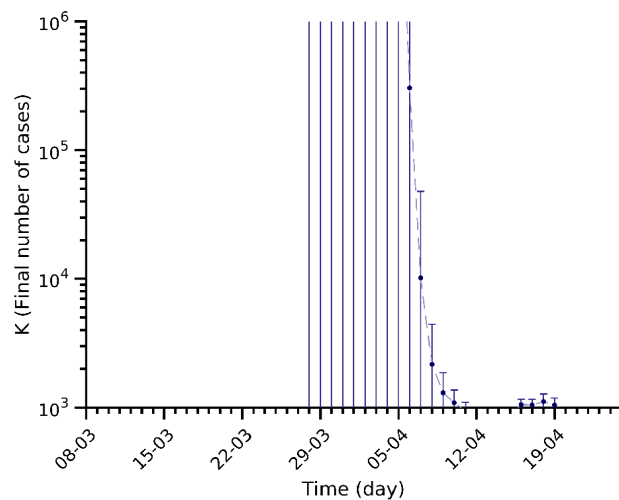
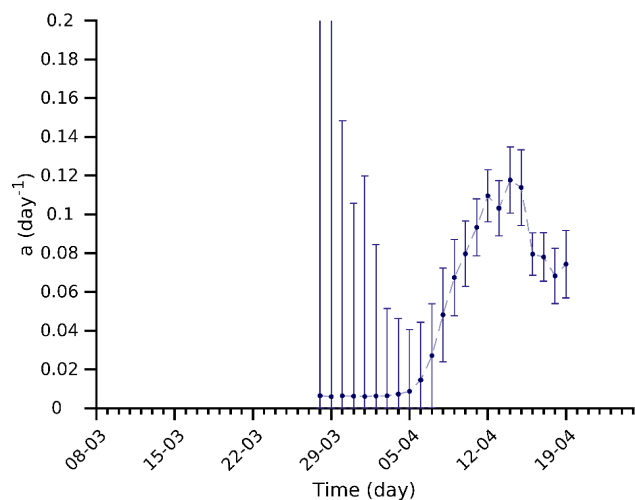
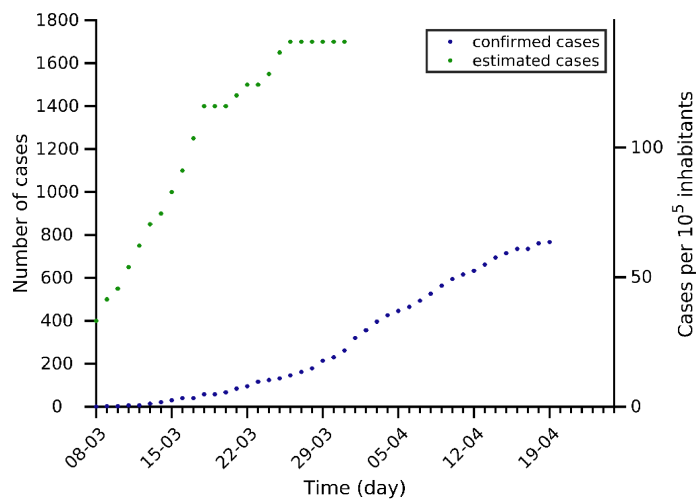
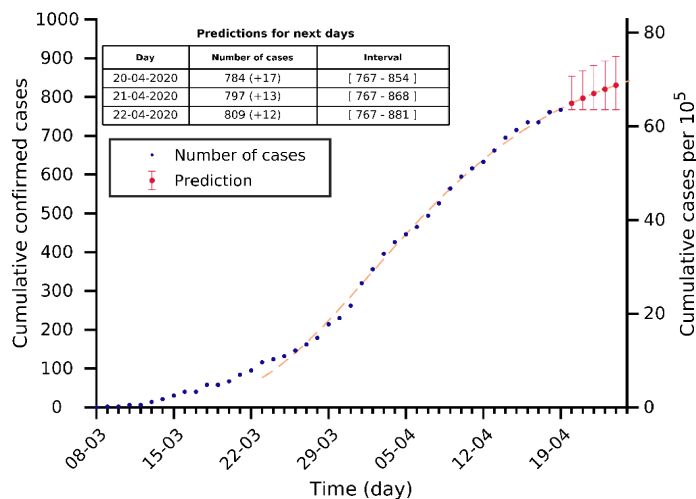
Slovakia 19-04-2020. Population: 5.5M. Current cumulated incidence: 21/10⁵



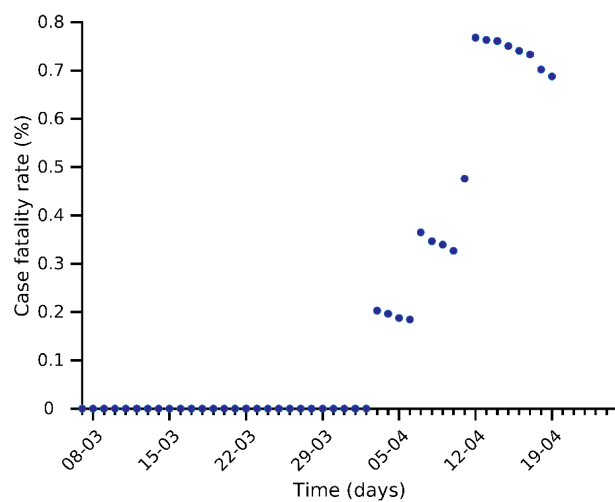
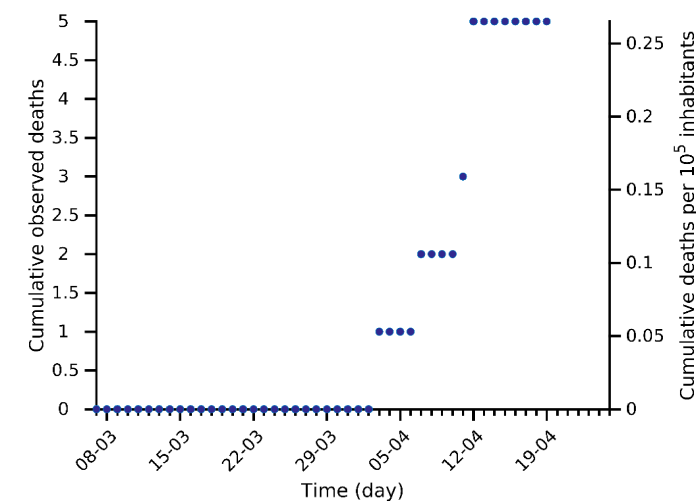
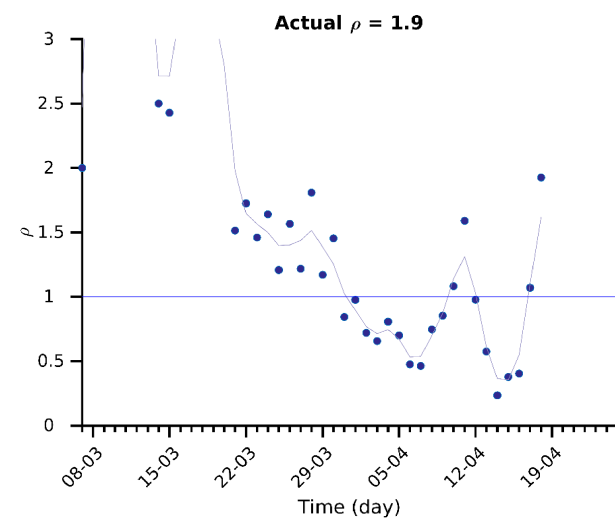
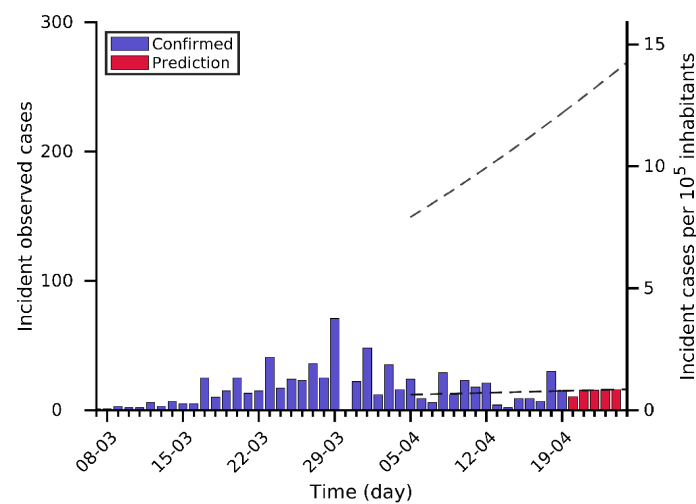
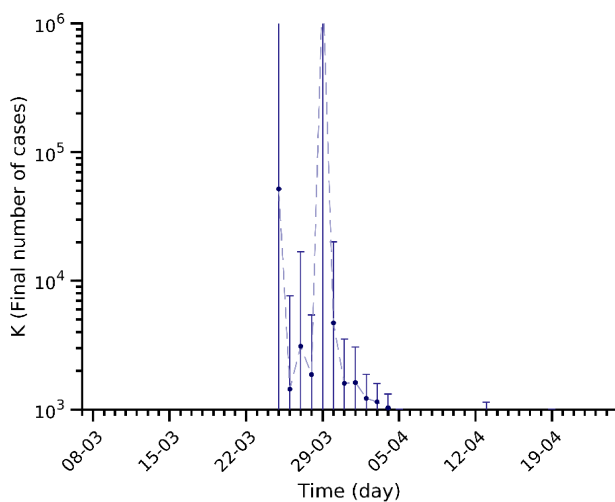
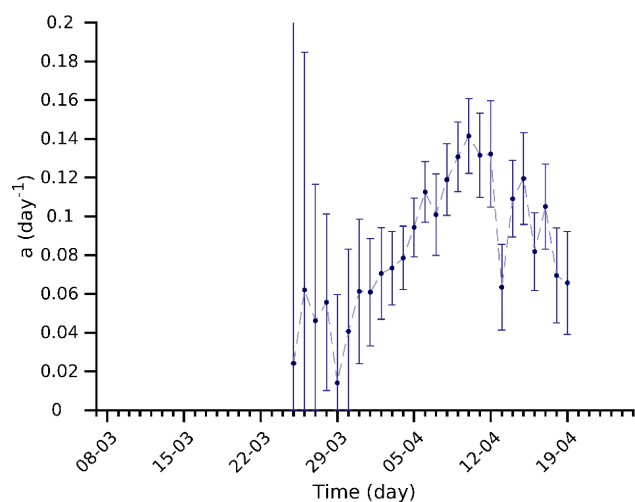
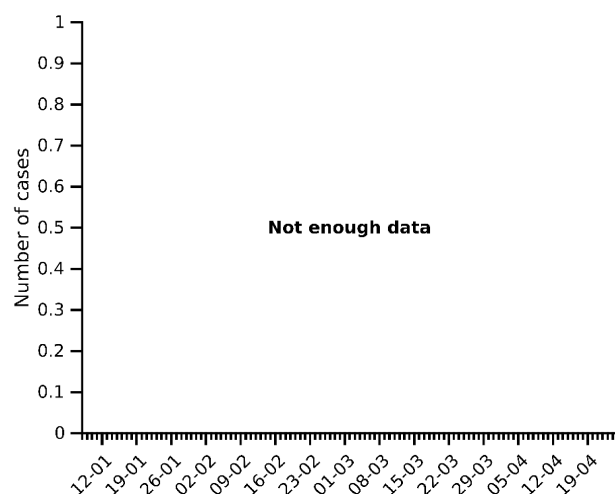
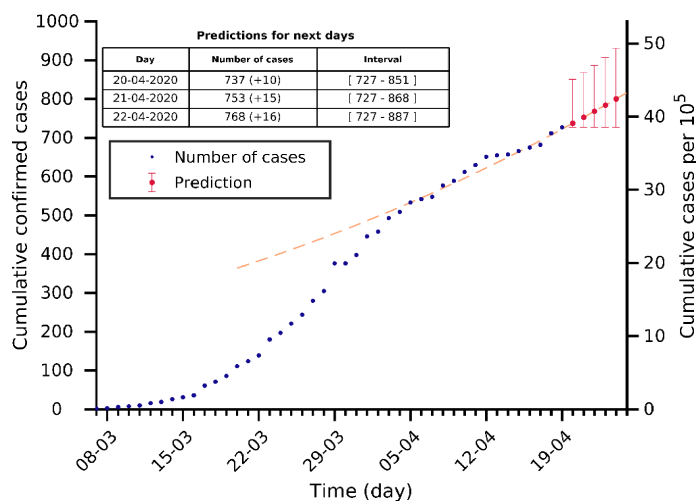
Bulgaria 19-04-2020. Population: 6.9M. Current cumulated incidence: 13/10⁵



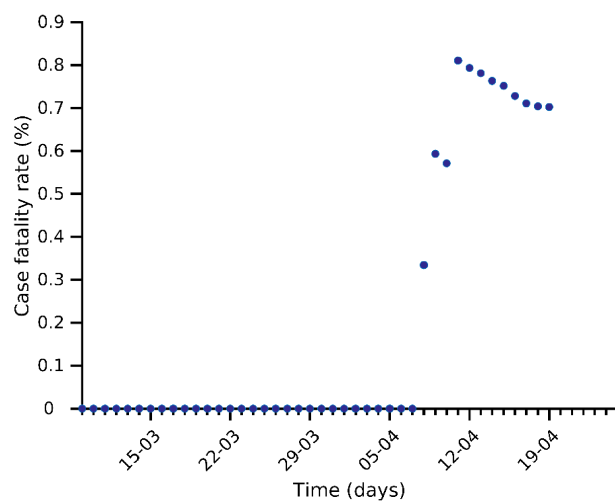
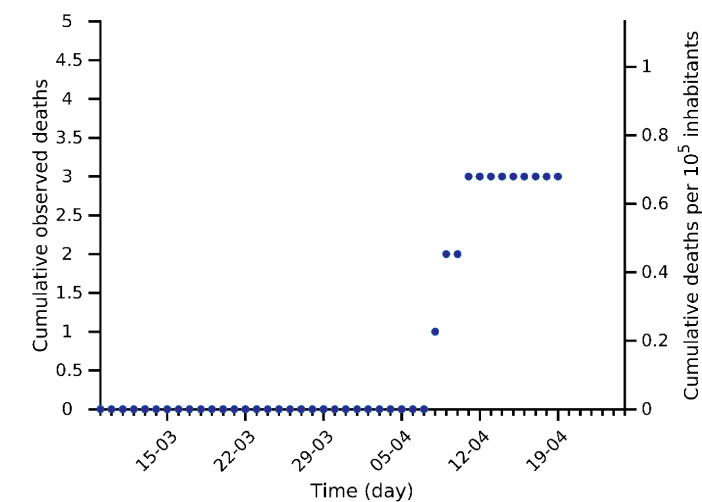
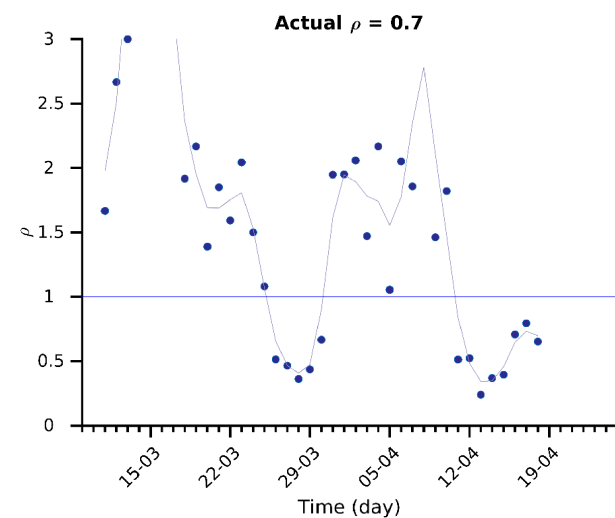
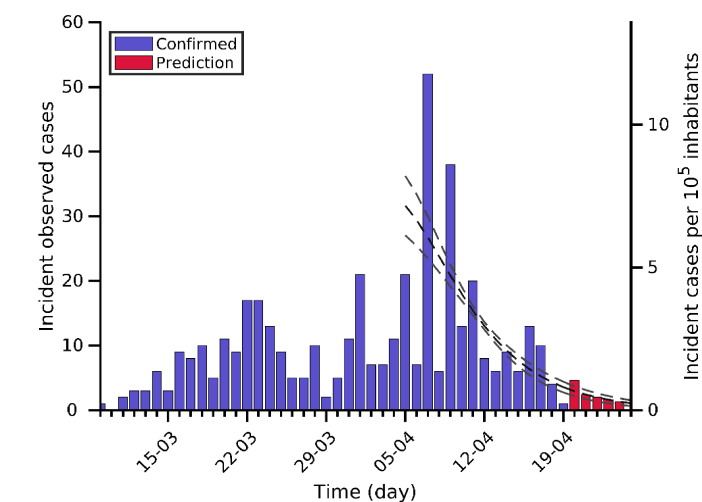
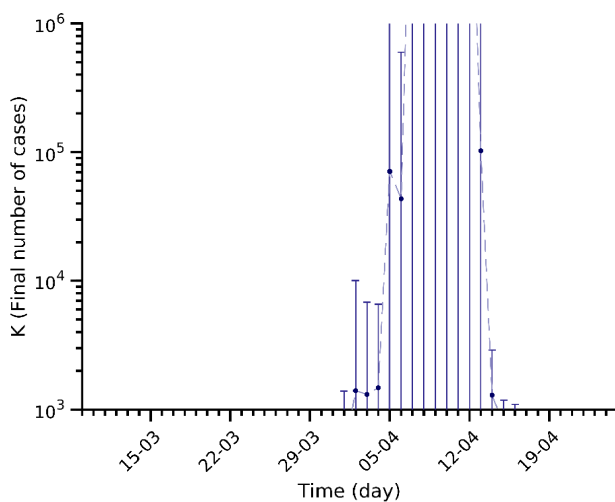
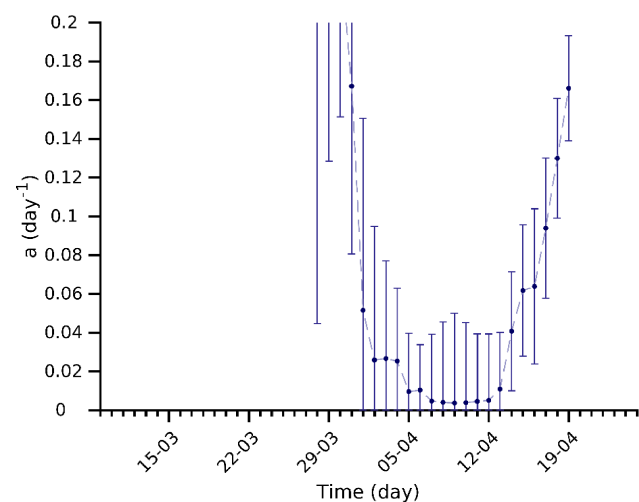
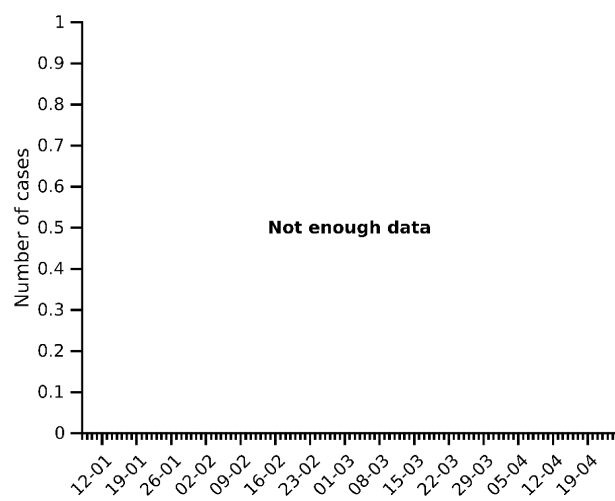
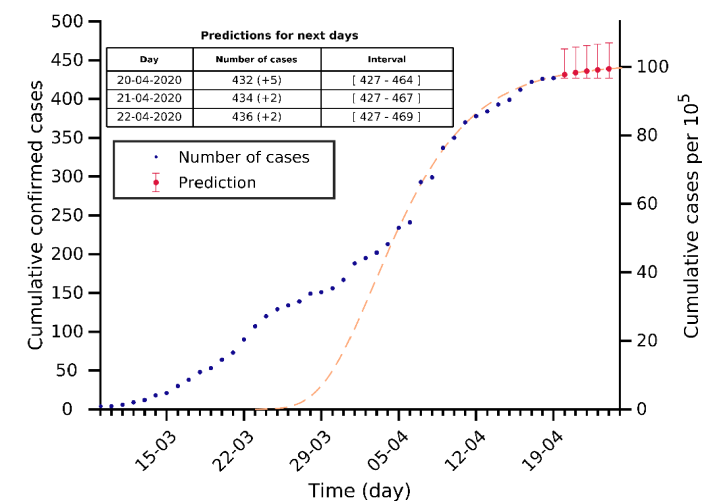
Cyprus 19-04-2020. Population: 1.2M. Current cumulated incidence: 64/10⁵



Latvia 19-04-2020. Population: 1.9M. Current cumulated incidence: 39/10⁵



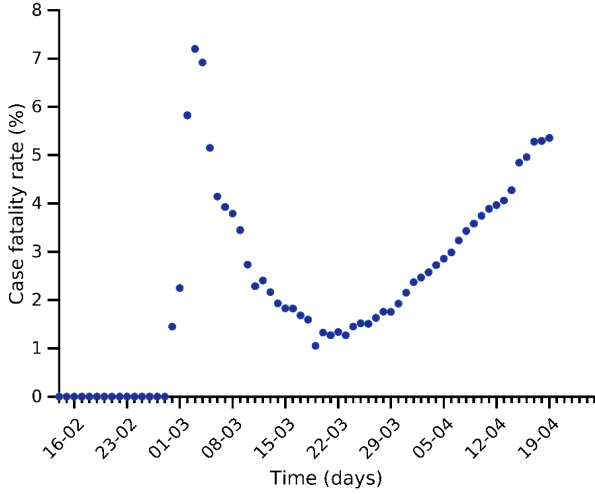
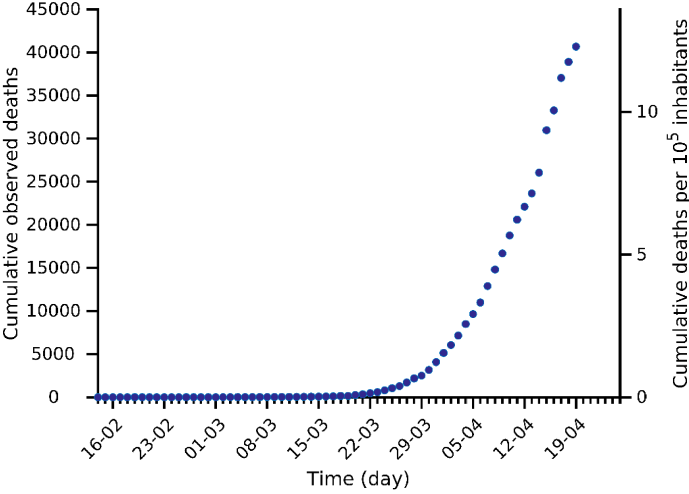
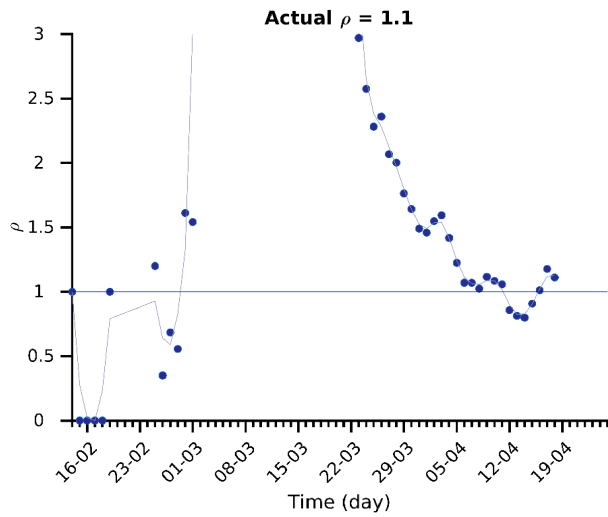
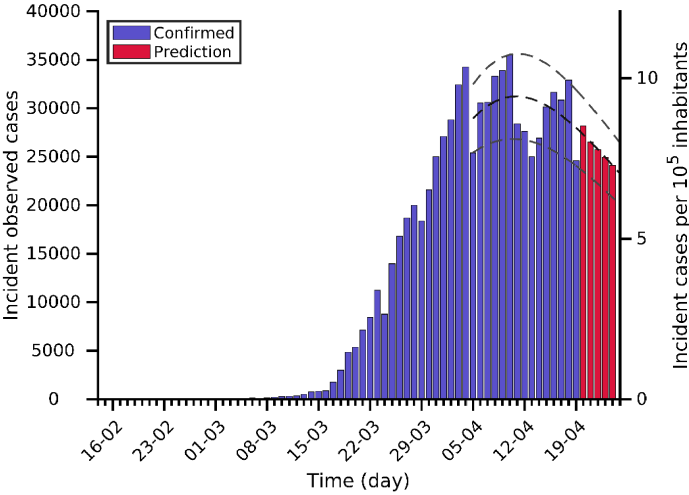
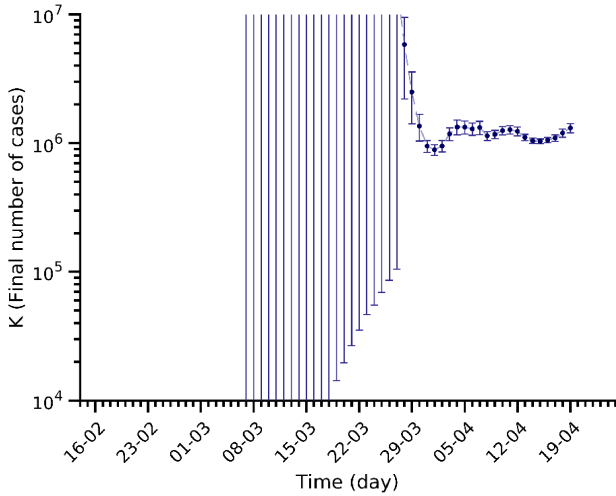
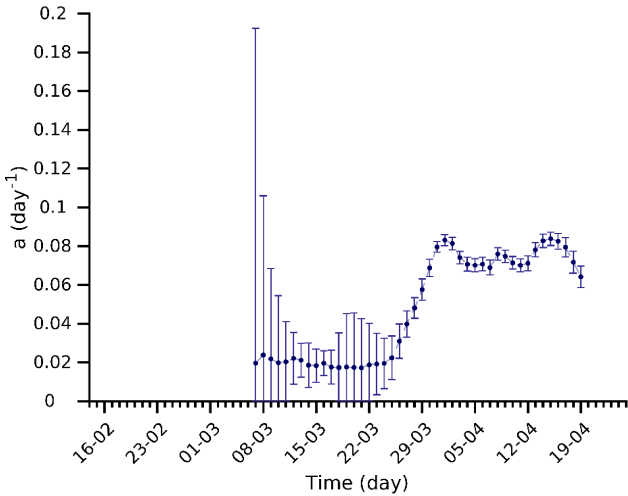
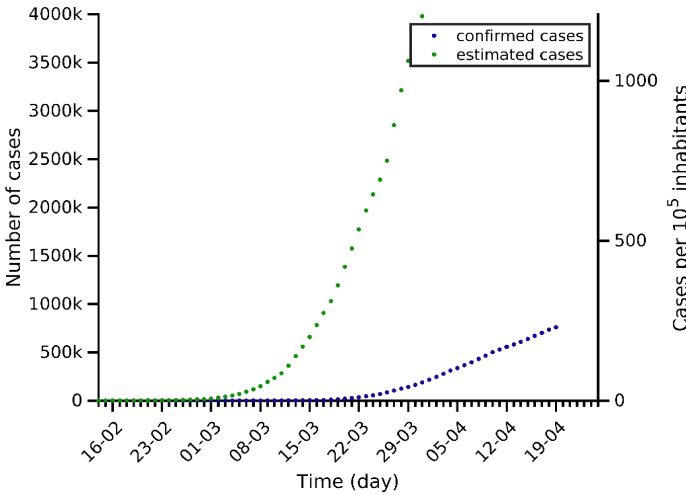
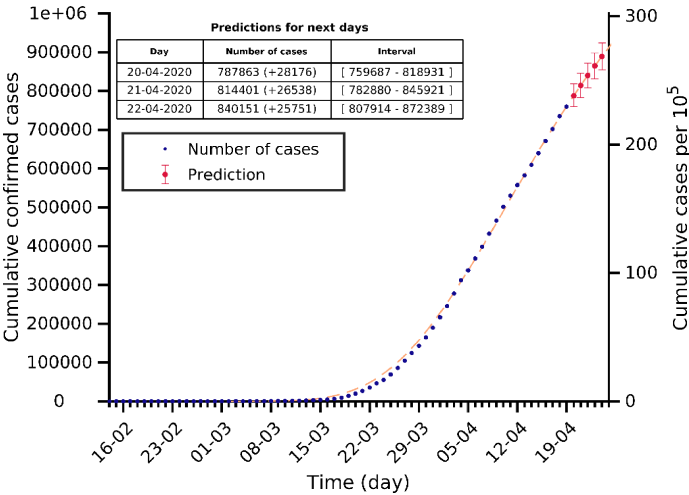
Malta 19-04-2020. Population: 0.4M. Current cumulated incidence: 97/10⁵



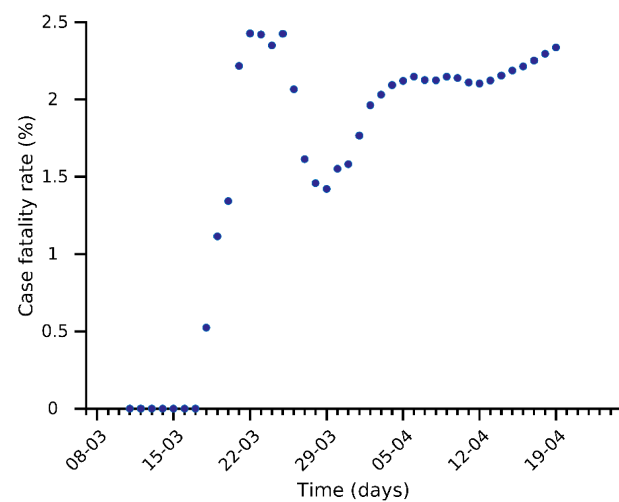
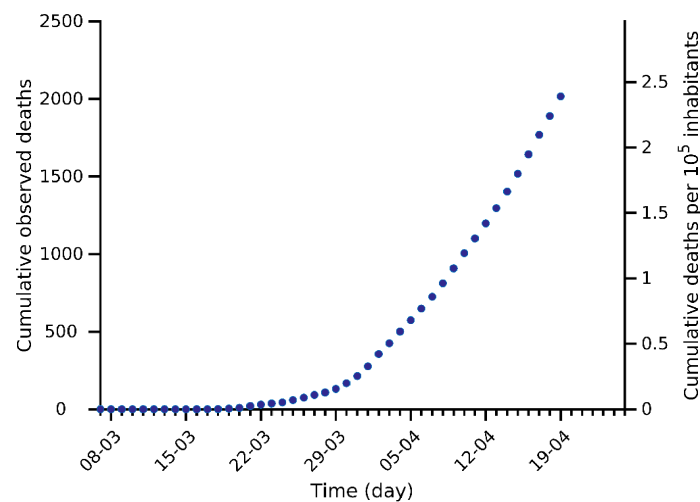
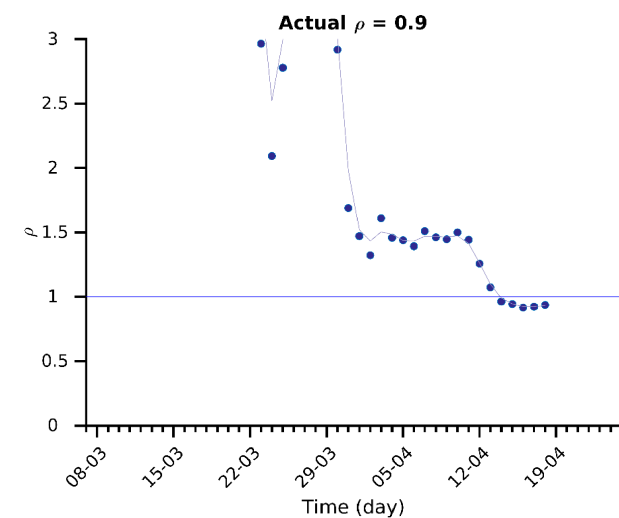
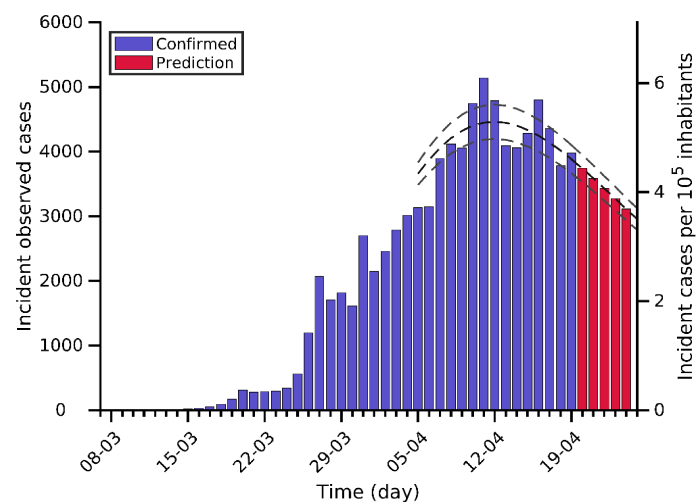
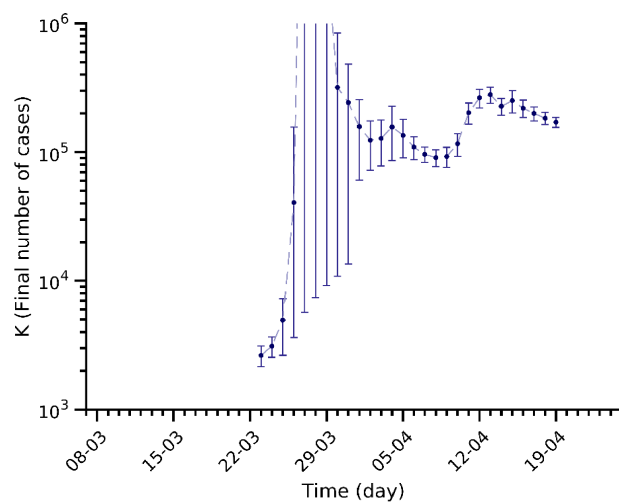
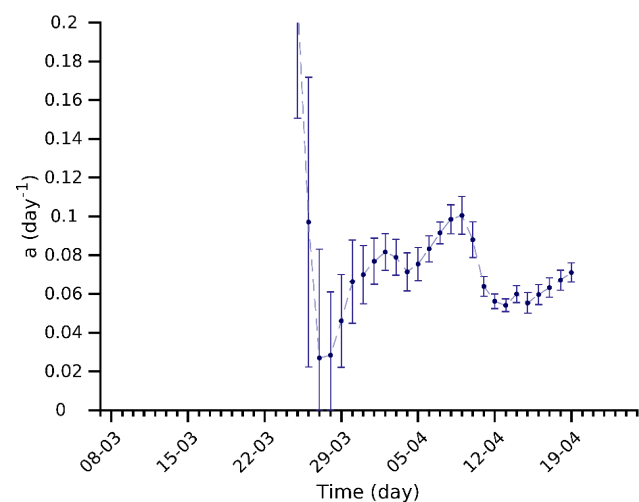
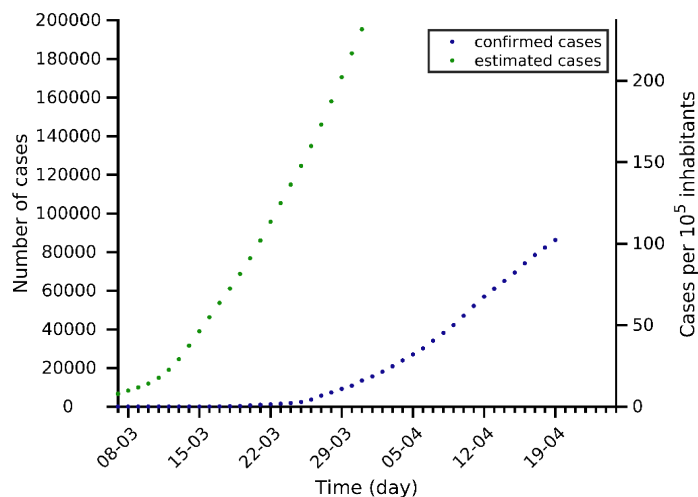
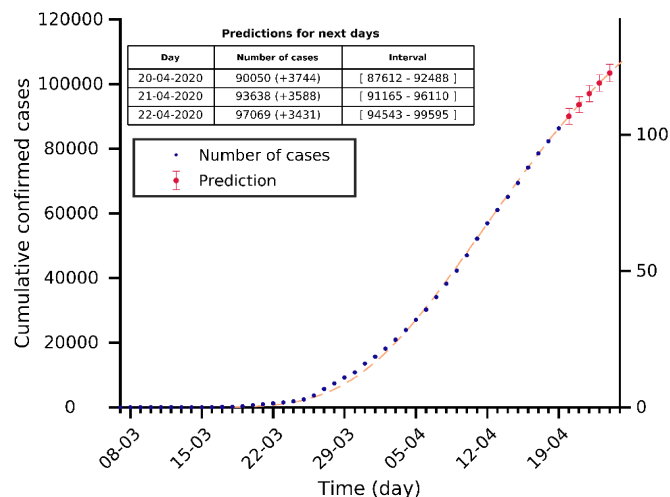
(2) Analysis and prediction of COVID-19 for other countries

Data obtained from <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

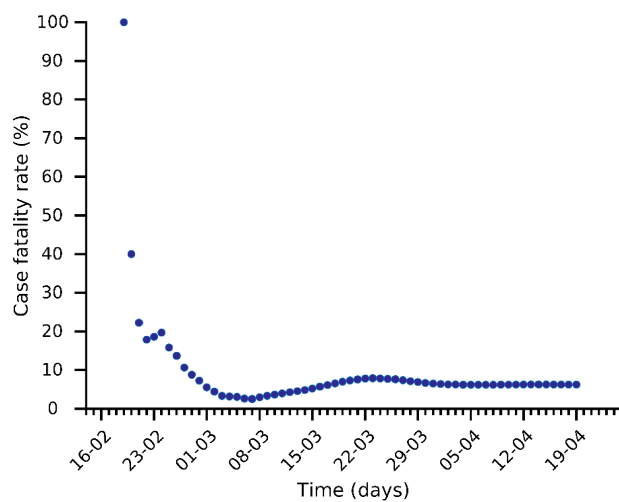
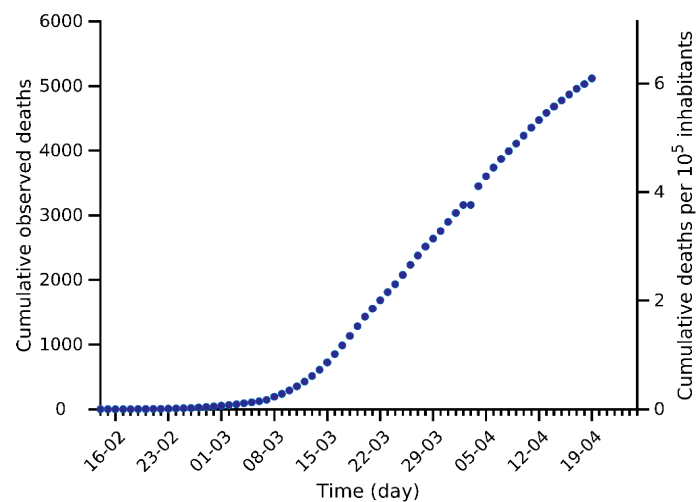
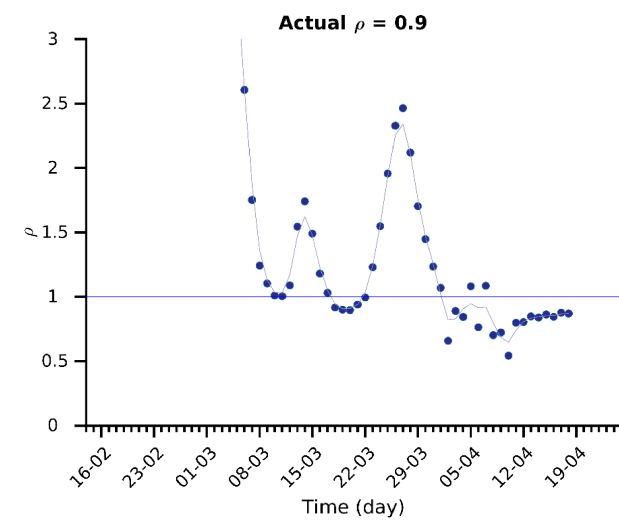
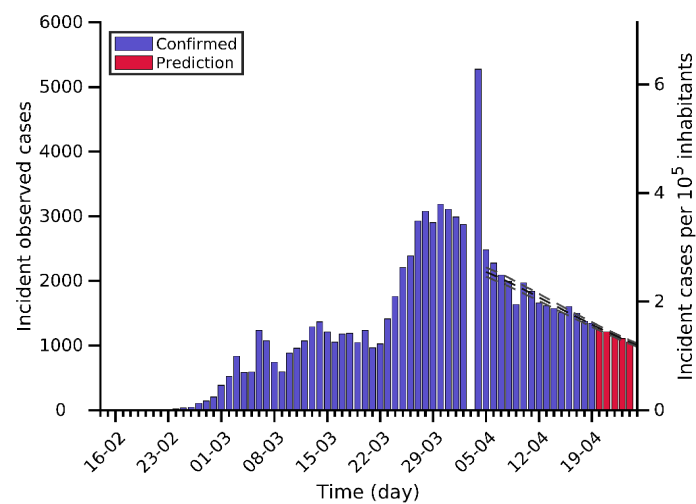
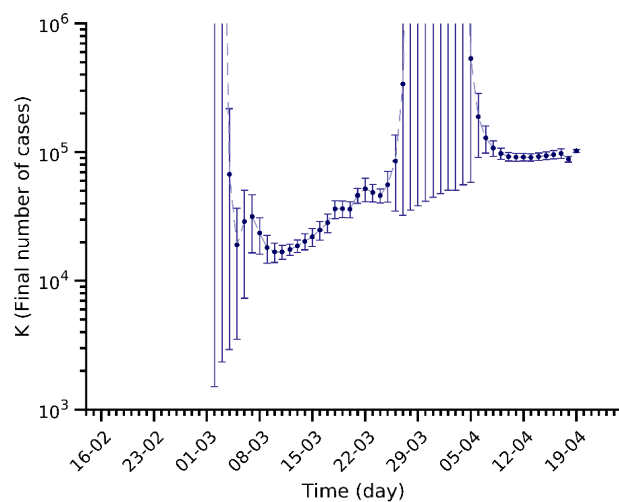
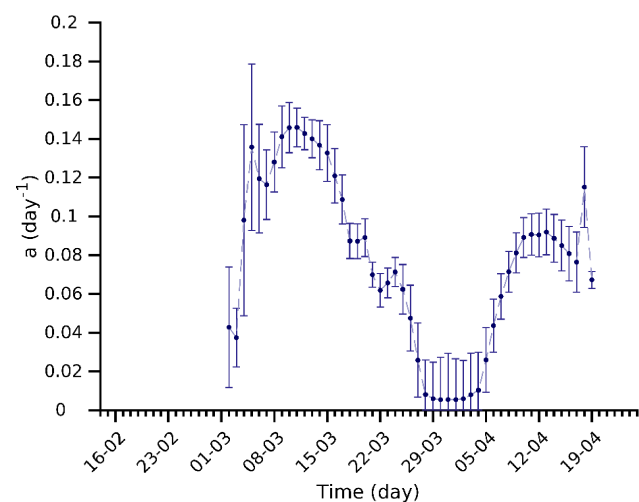
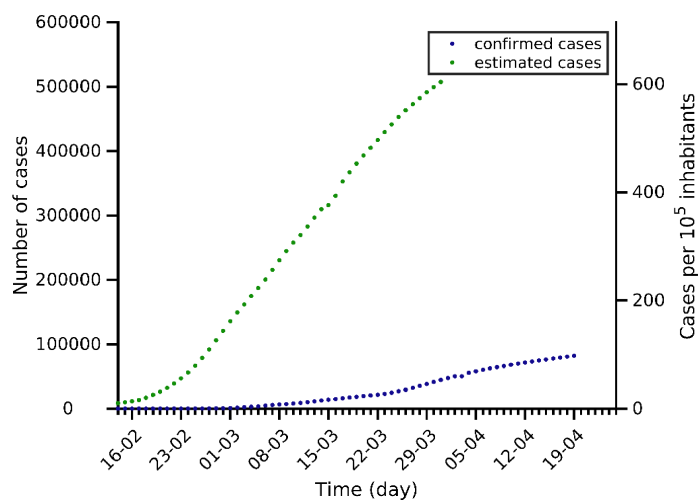
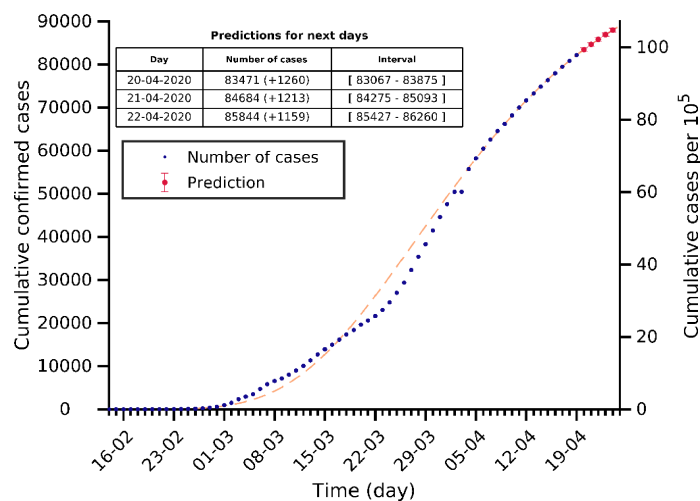
USA 19-04-2020. Population: 331.0M. Current cumulated incidence: 230/10⁵



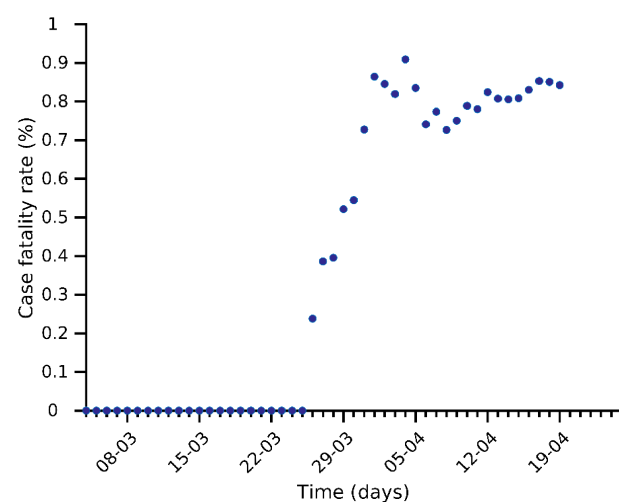
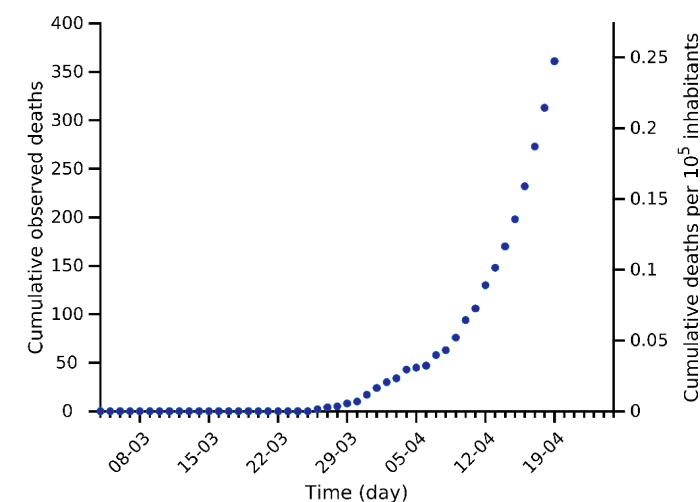
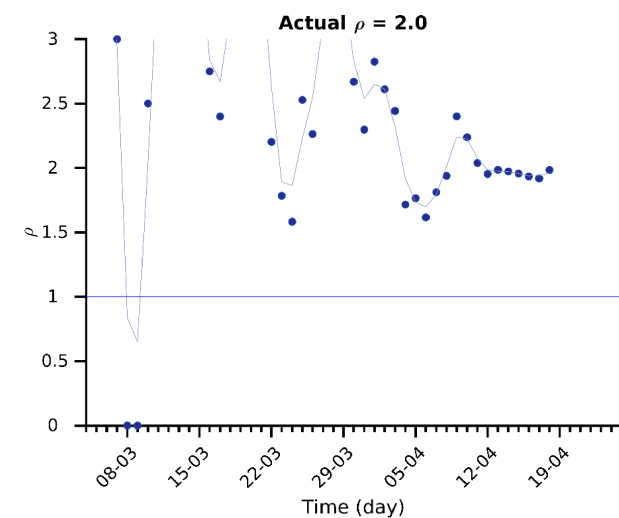
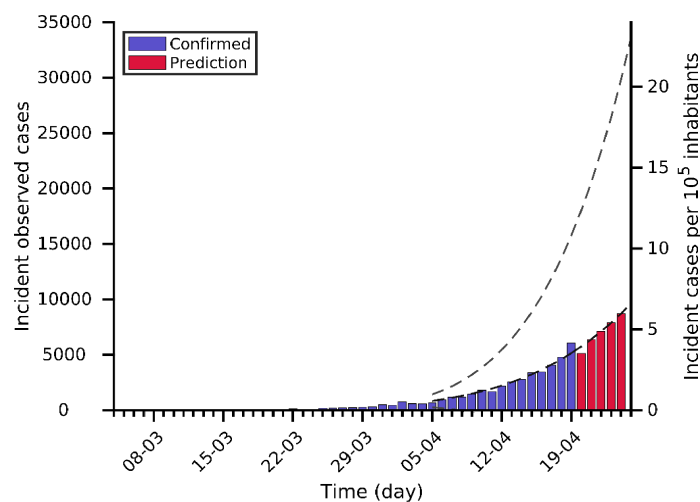
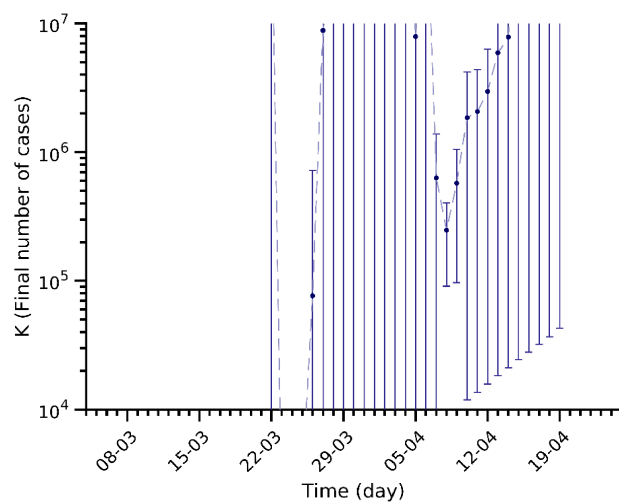
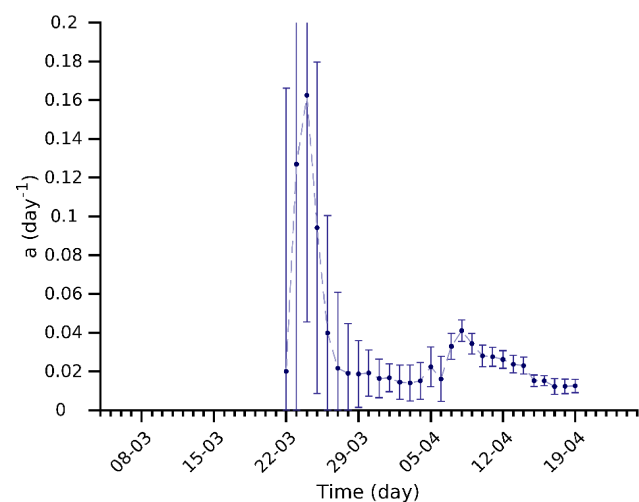
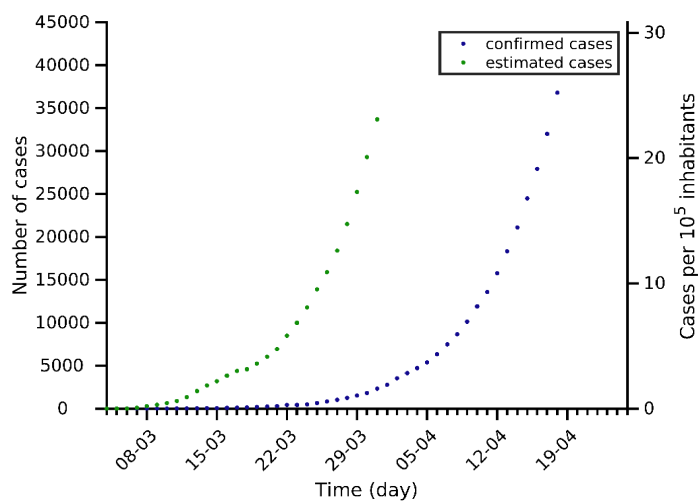
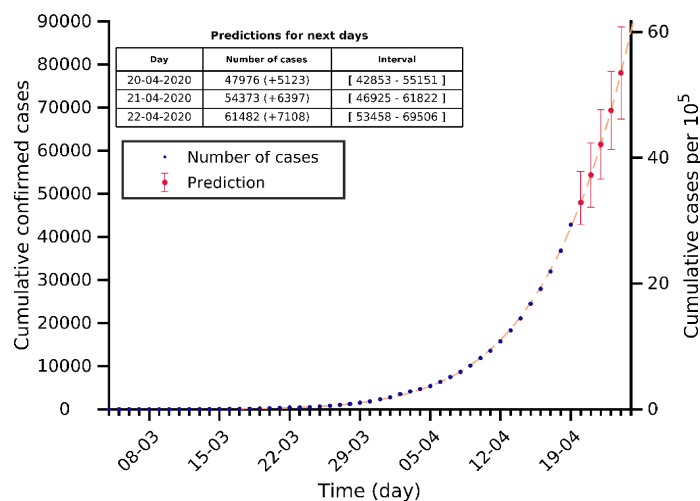
Turkey 19-04-2020. Population: 84.3M. Current cumulated incidence: 102/10⁵



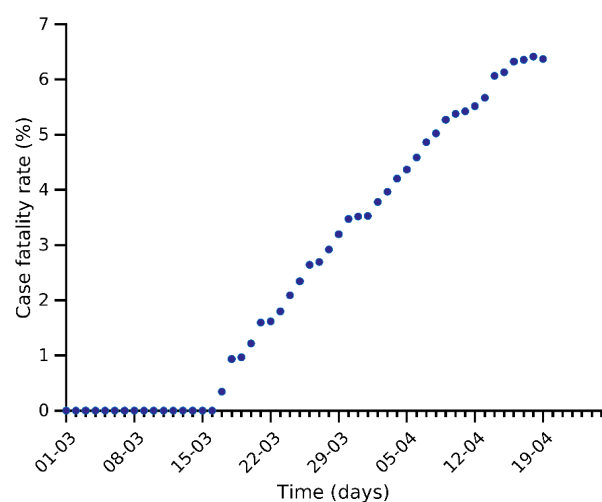
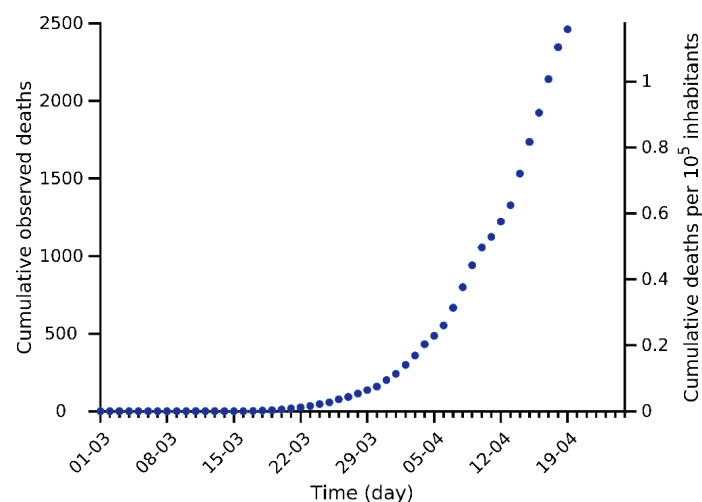
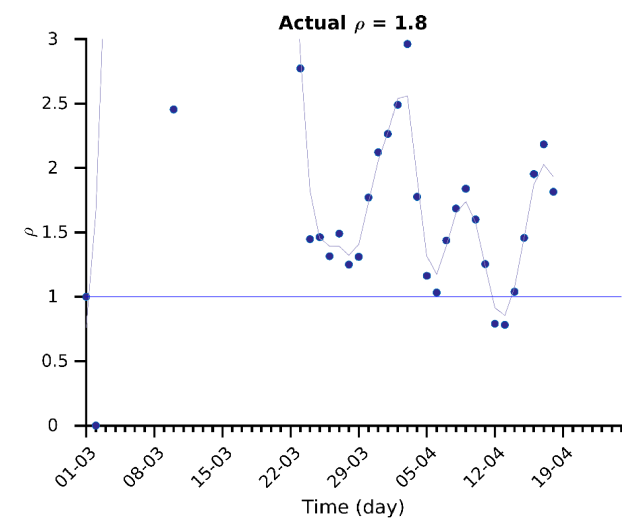
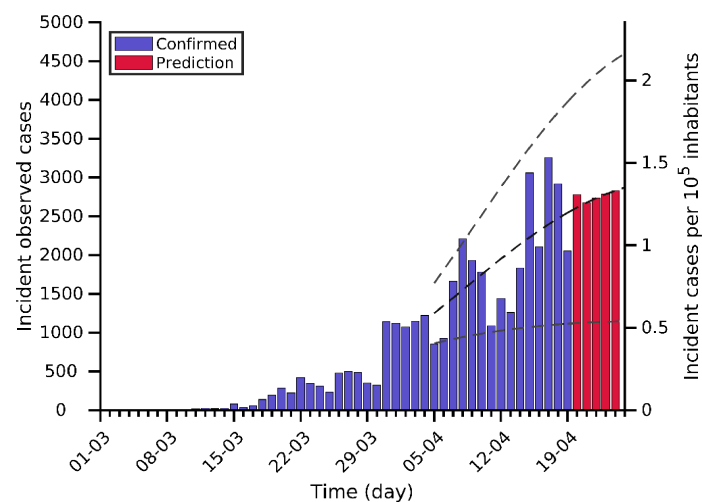
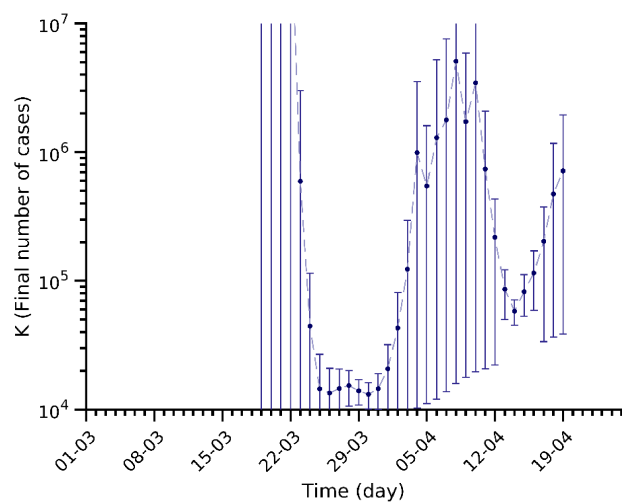
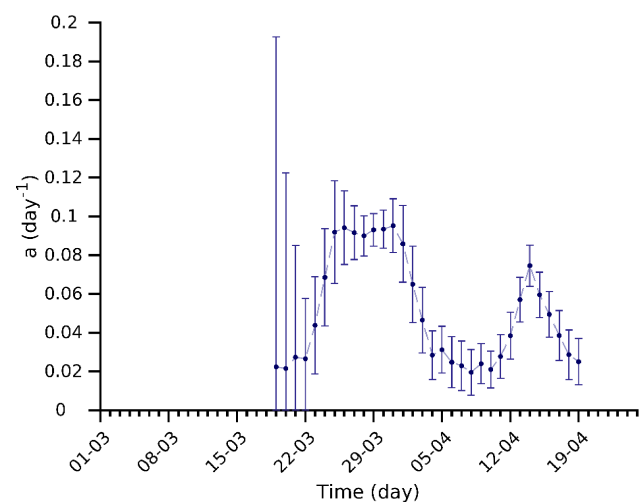
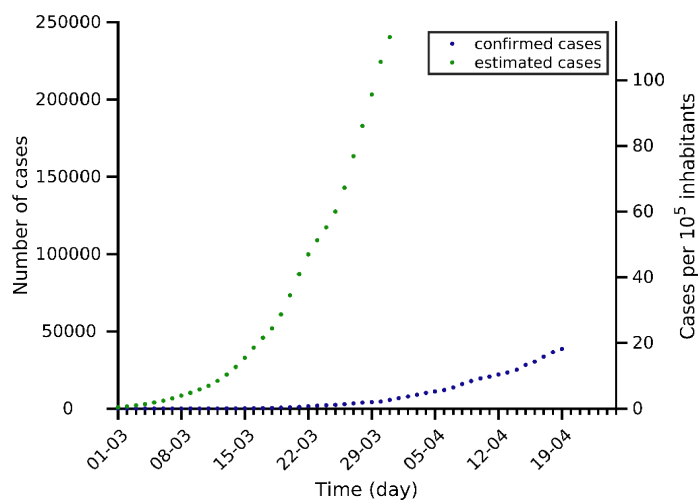
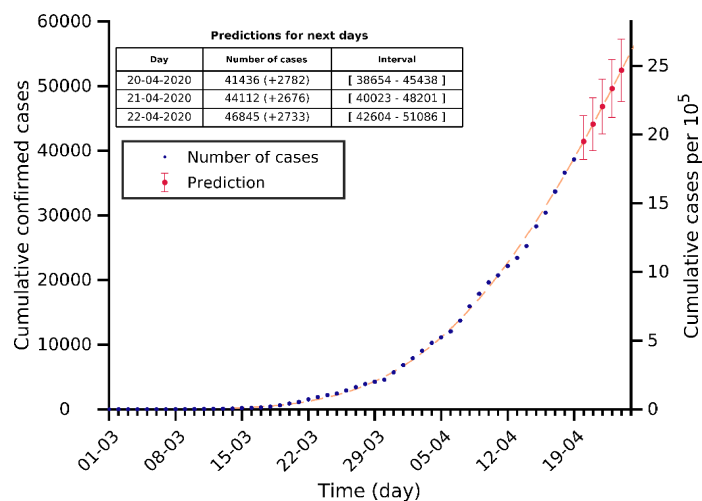
Iran 19-04-2020. Population: 84.0M. Current cumulated incidence: 98/10⁵



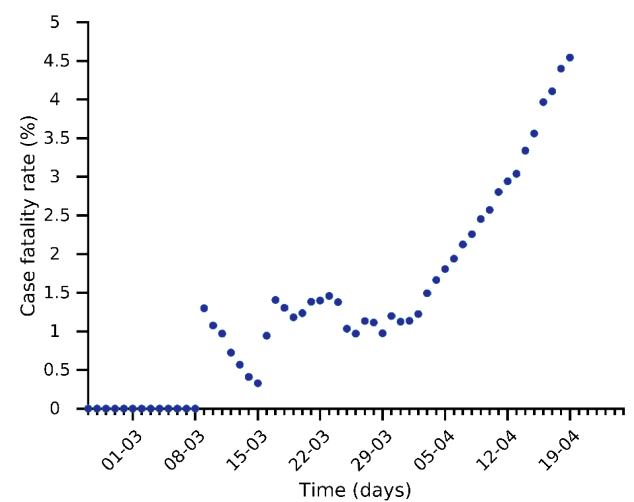
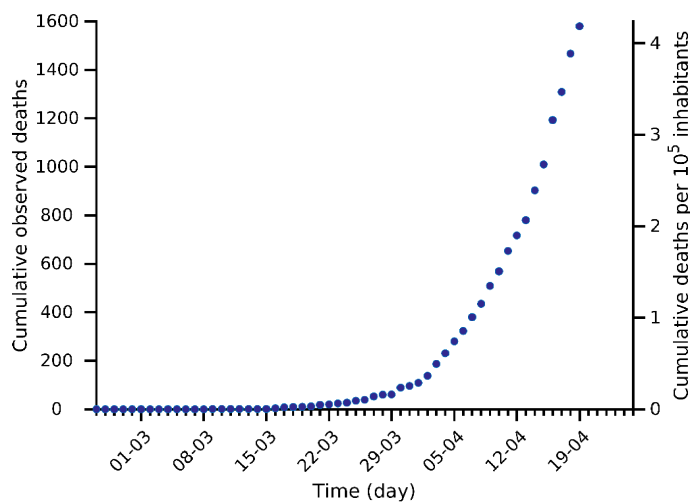
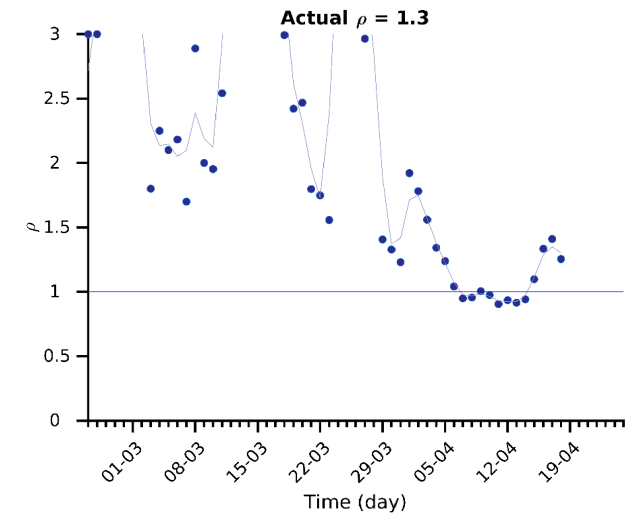
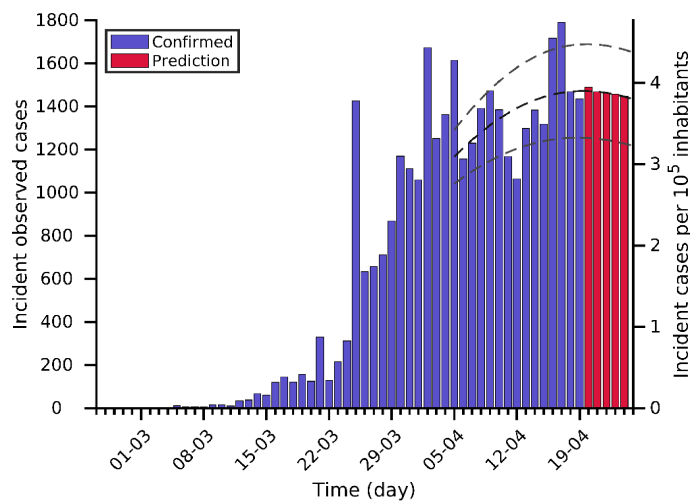
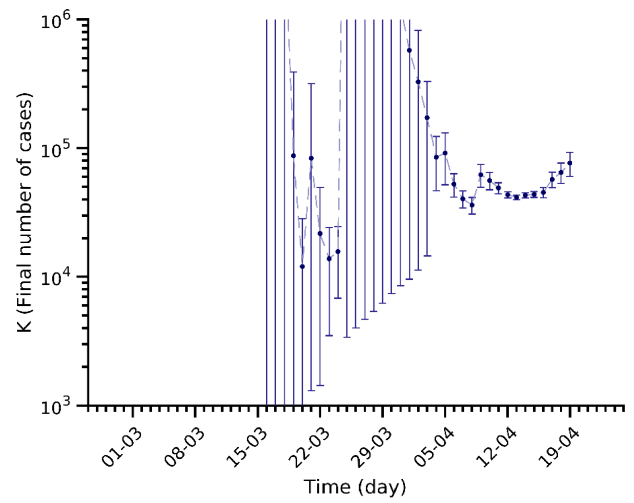
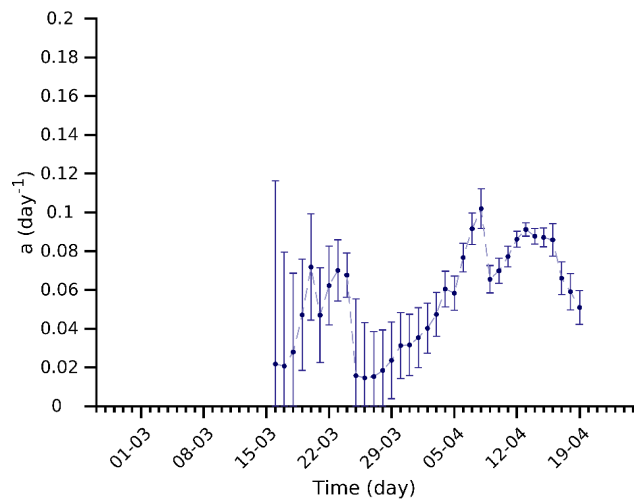
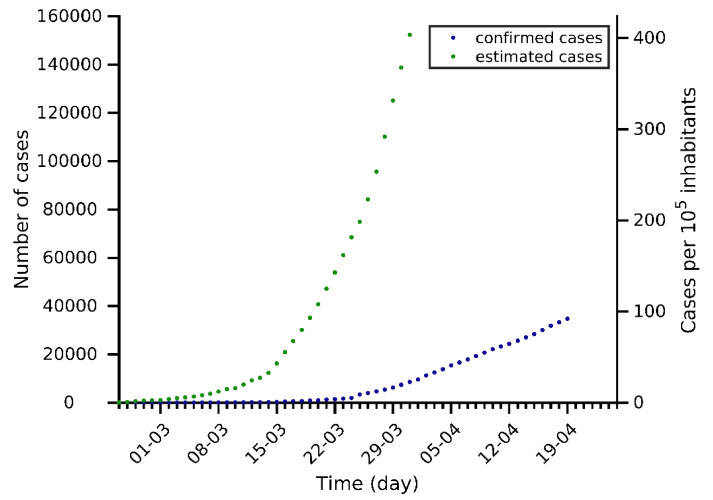
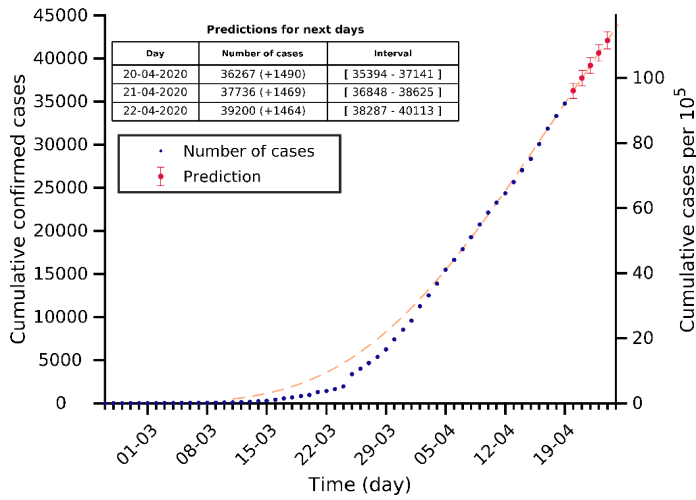
Russia 19-04-2020. Population: 145.9M. Current cumulated incidence: 29/10⁵



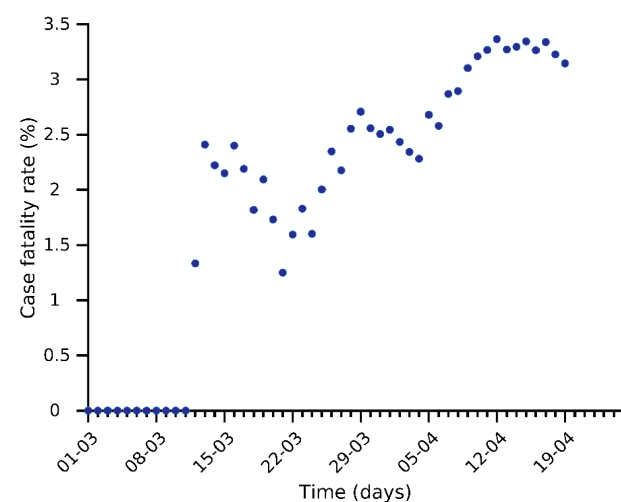
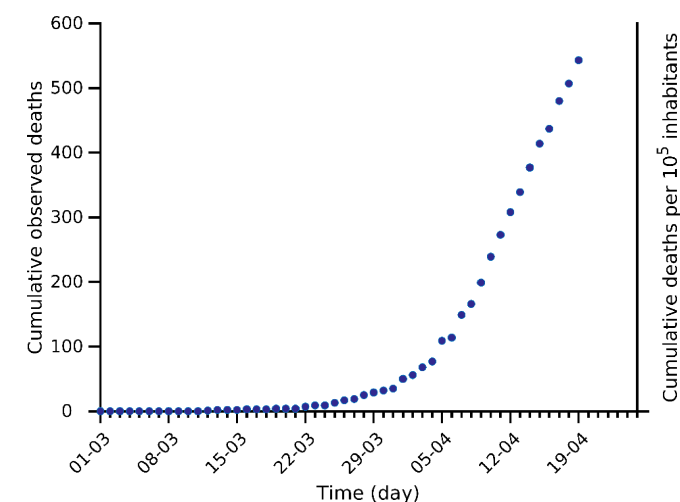
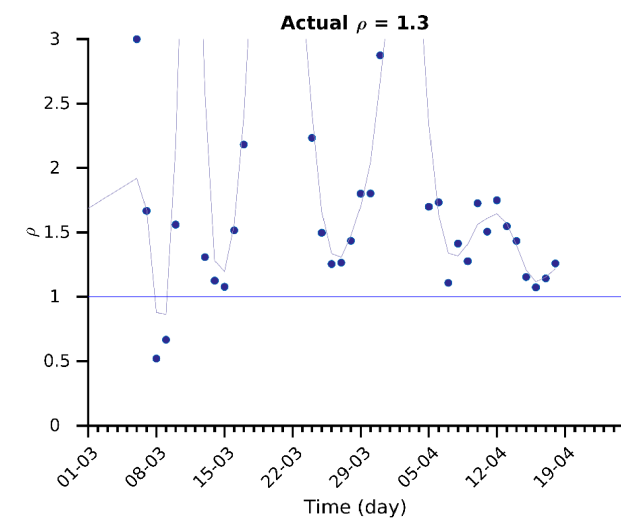
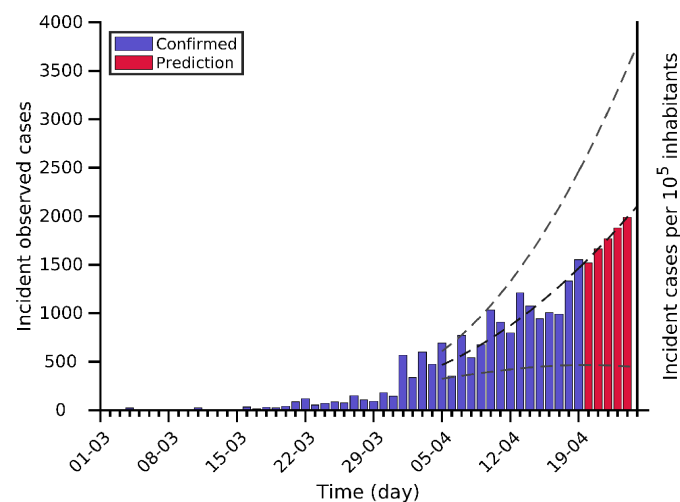
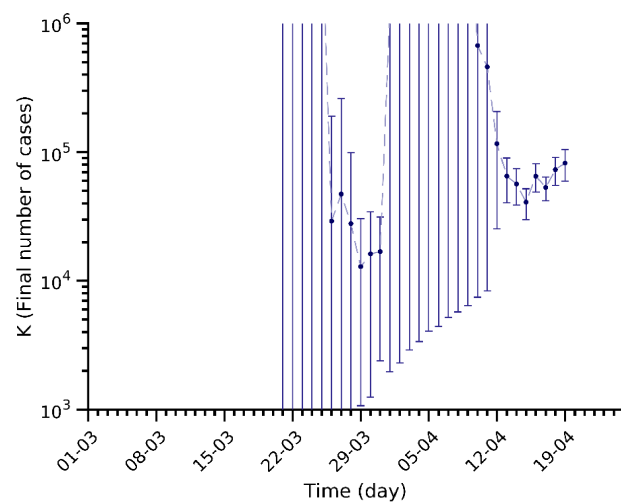
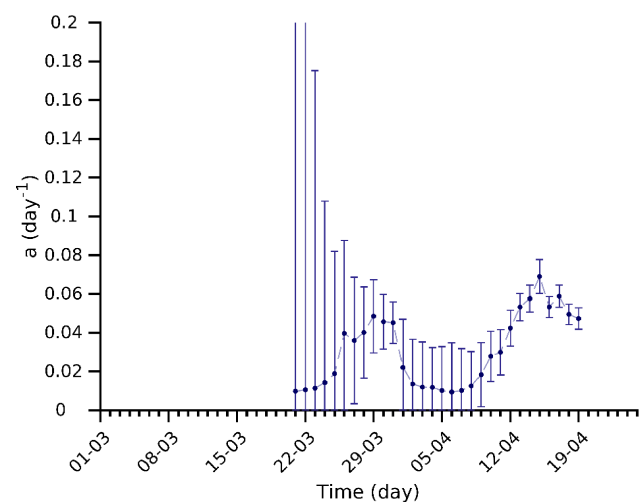
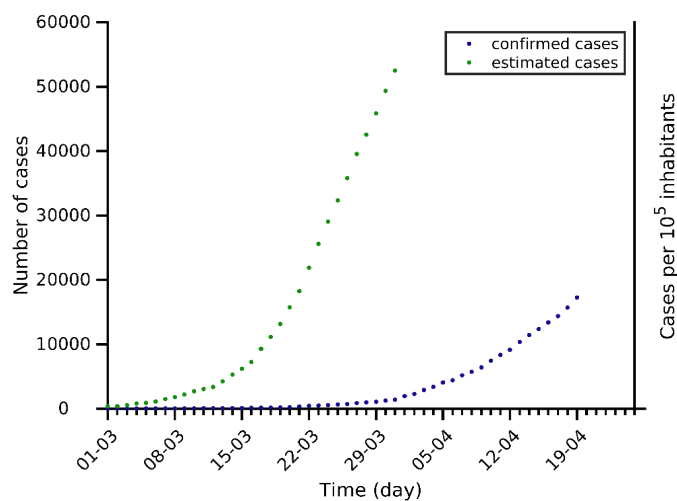
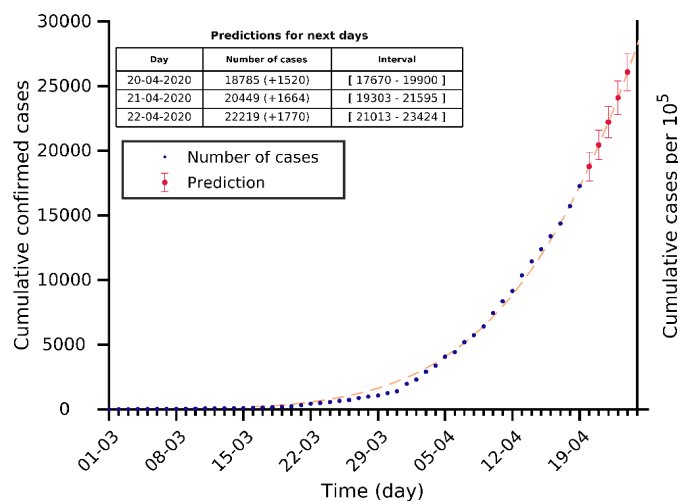
Brazil 19-04-2020. Population: 212.6M. Current cumulated incidence: 18/10⁵



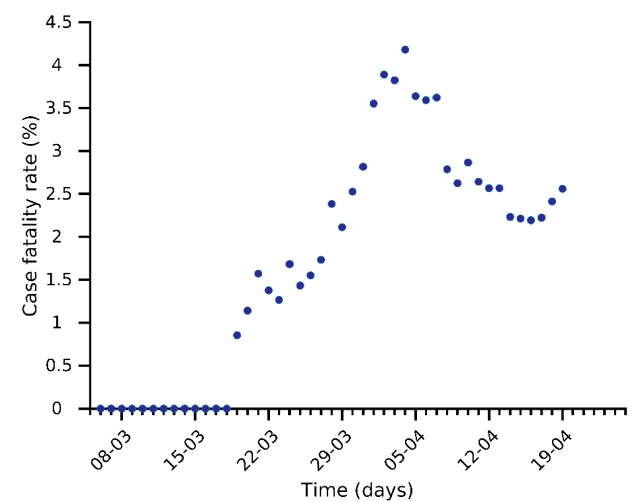
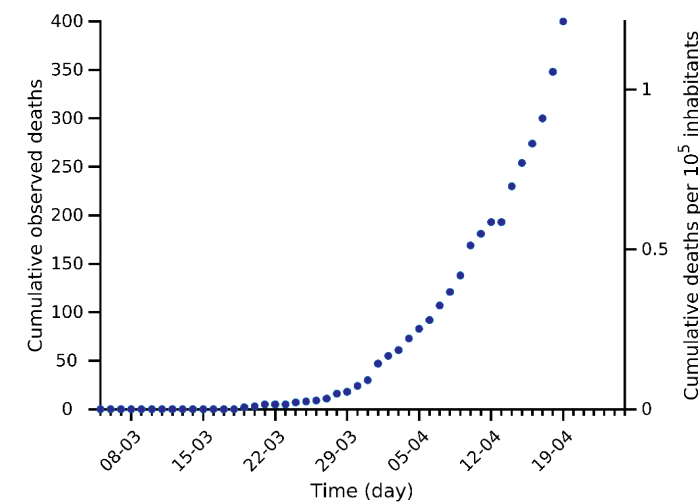
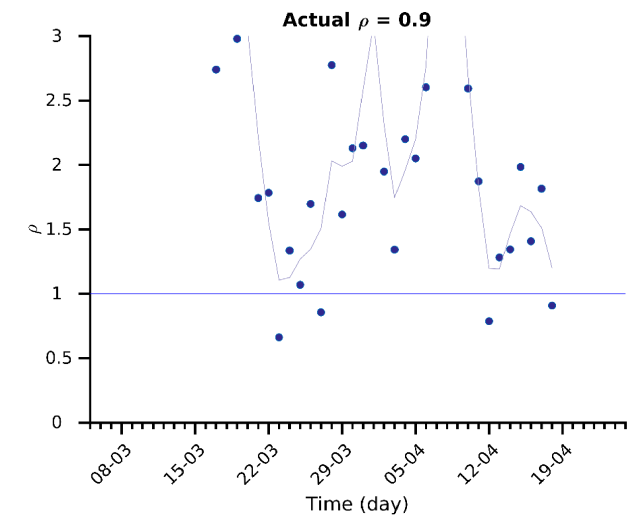
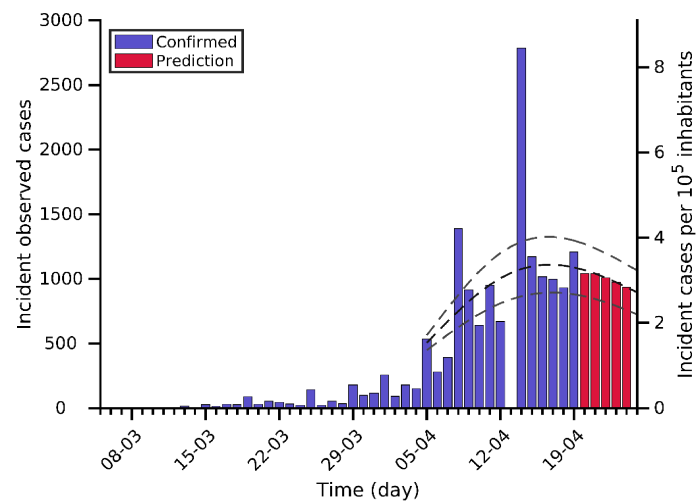
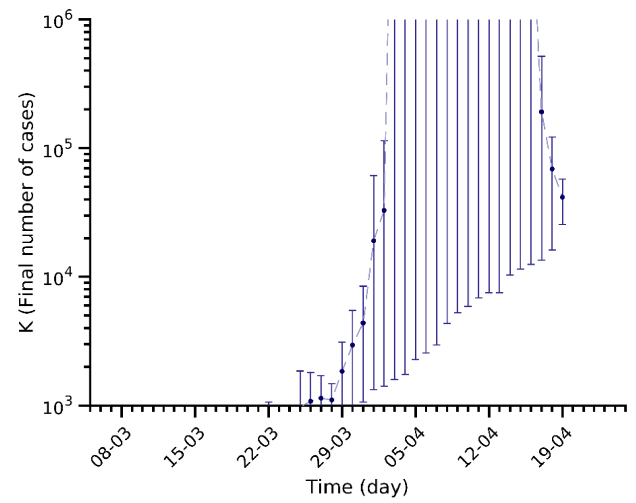
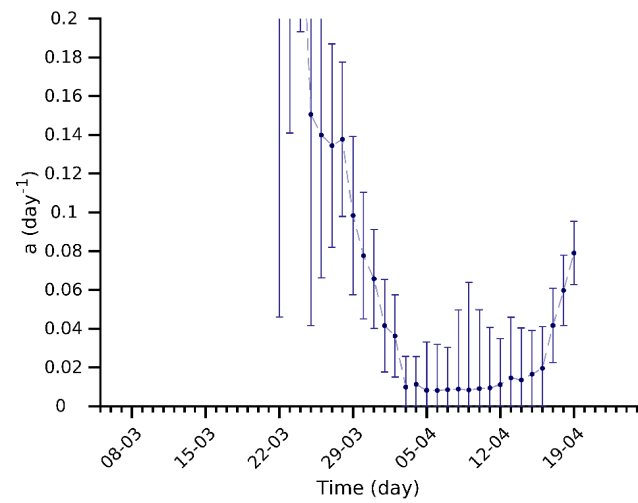
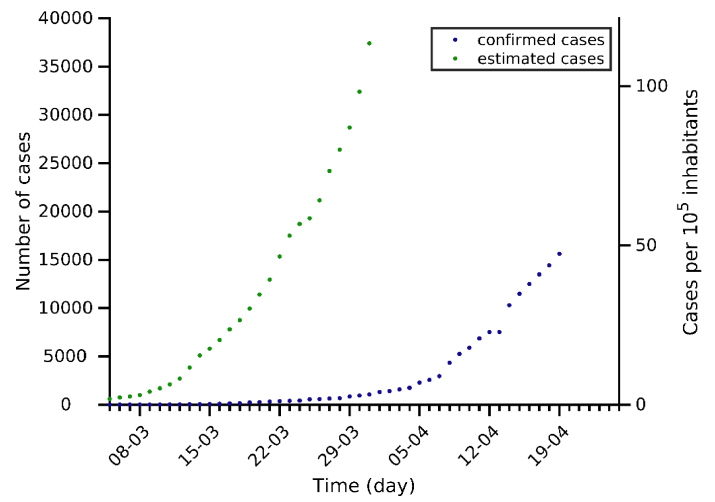
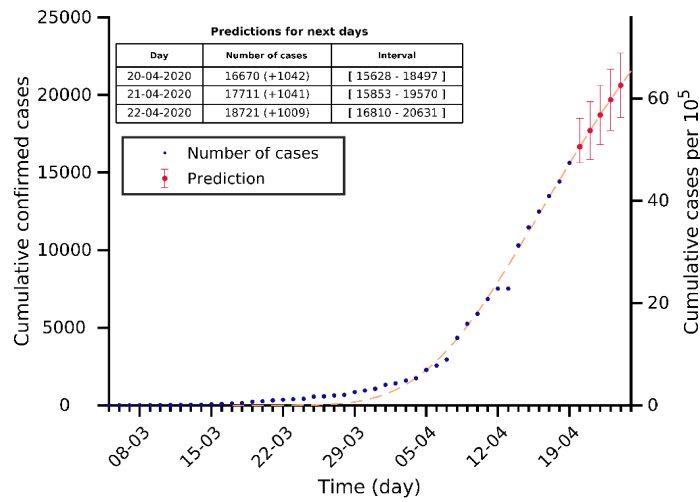
Canada 19-04-2020. Population: 37.7M. Current cumulated incidence: 92/10⁵



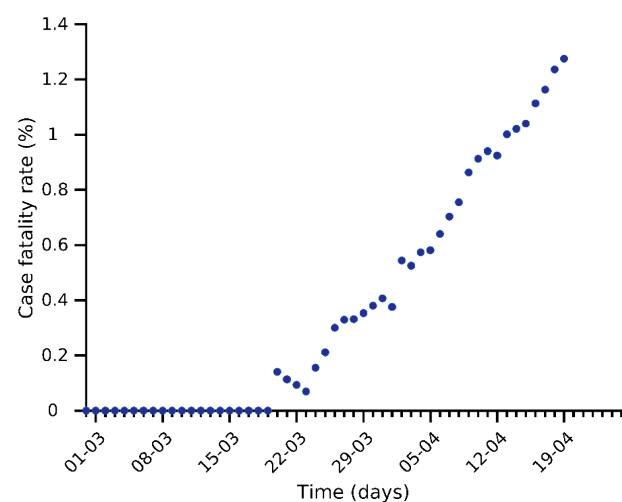
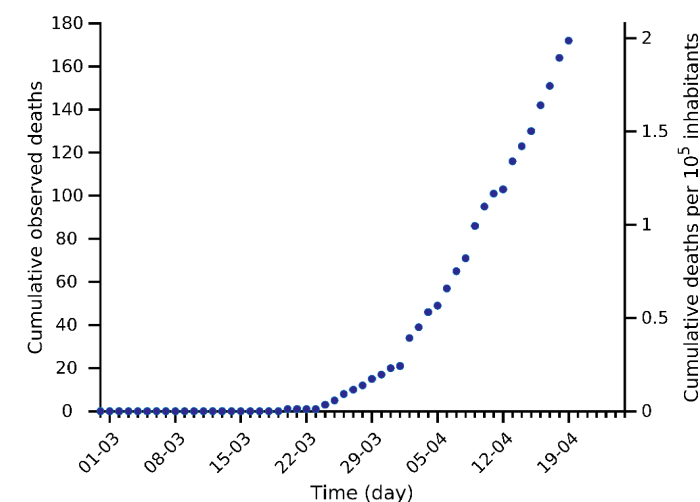
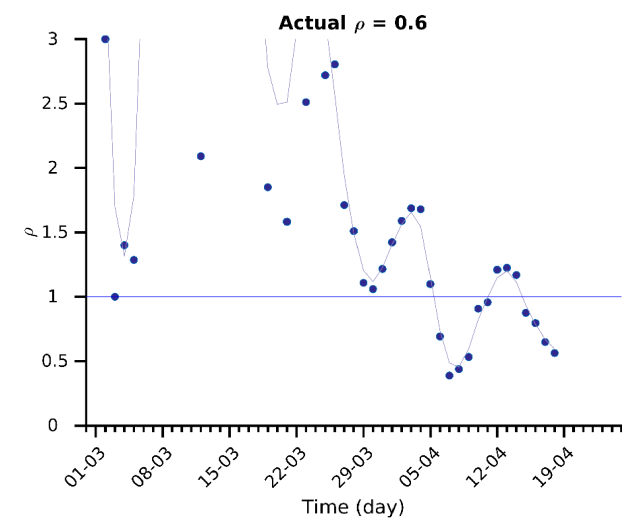
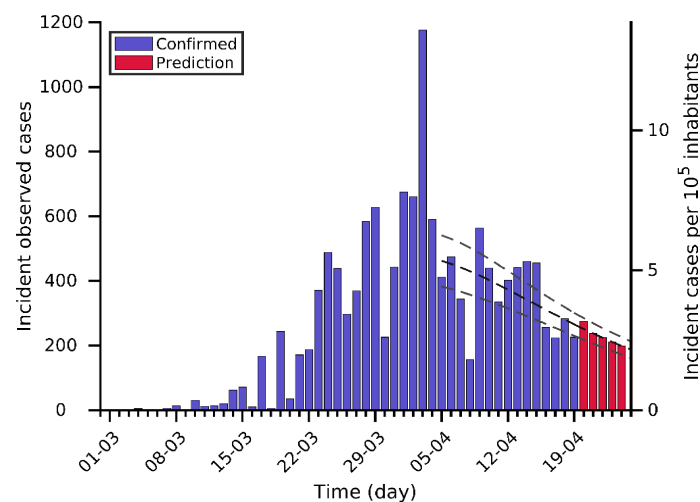
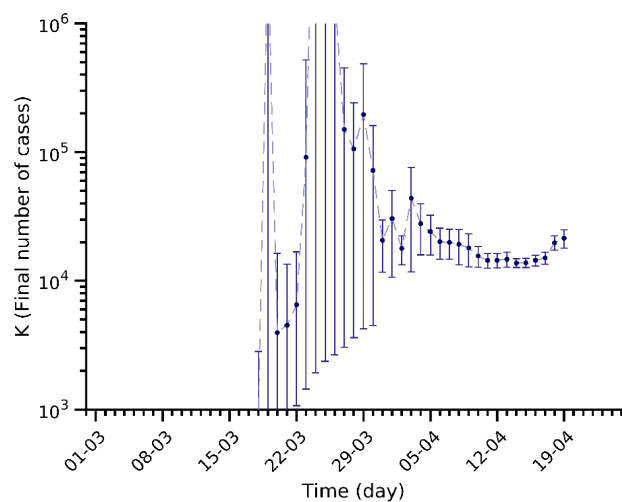
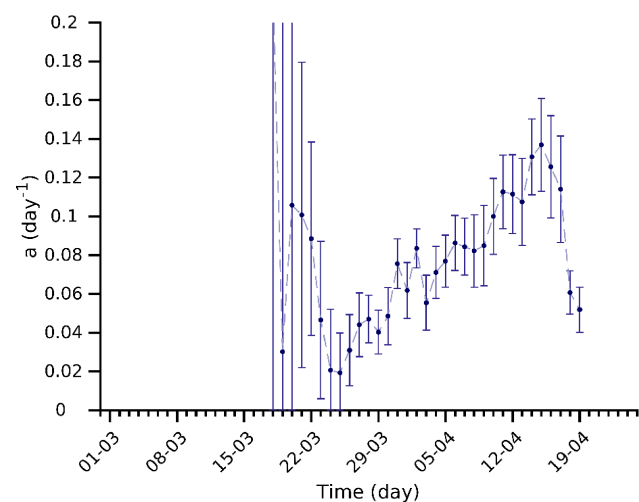
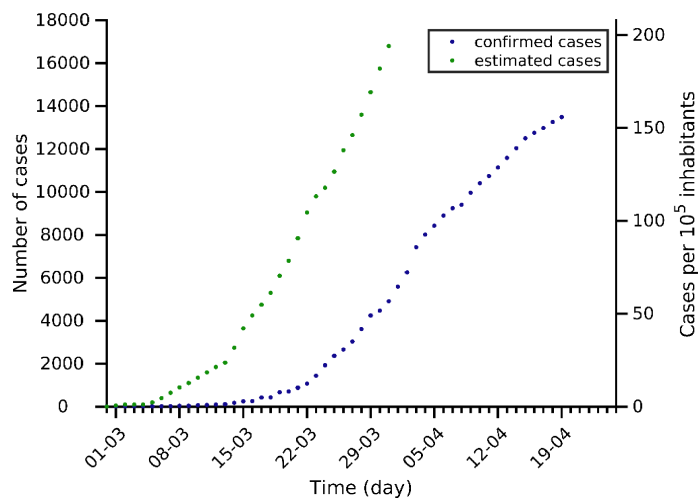
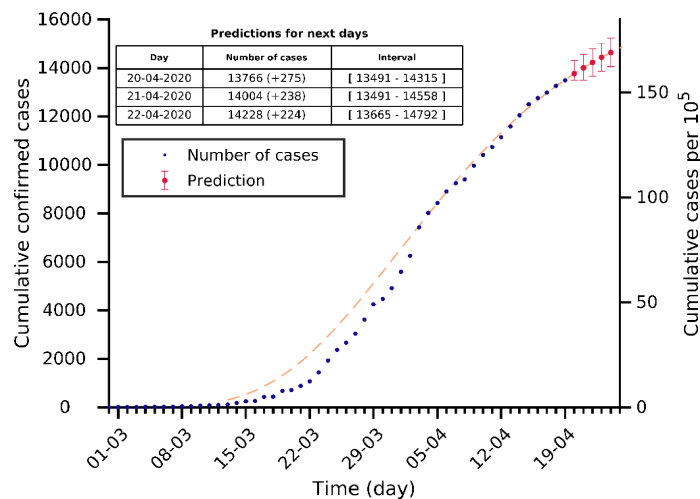
India 19-04-2020. Population: M. Current cumulated incidence: /10⁵



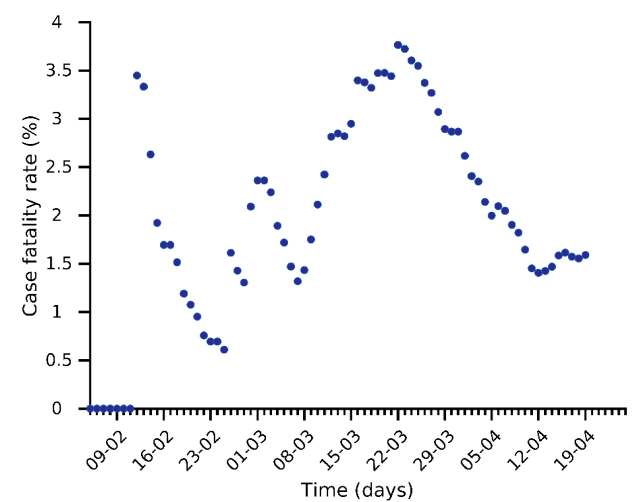
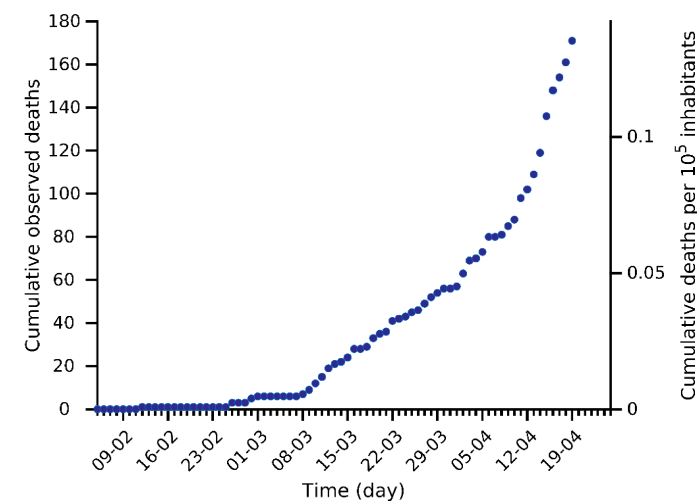
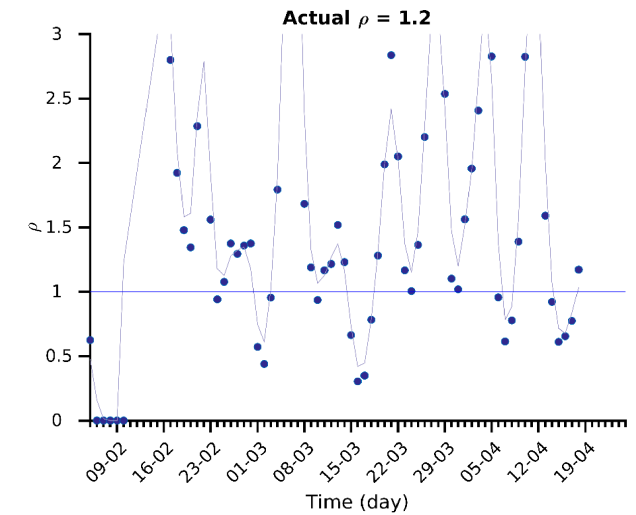
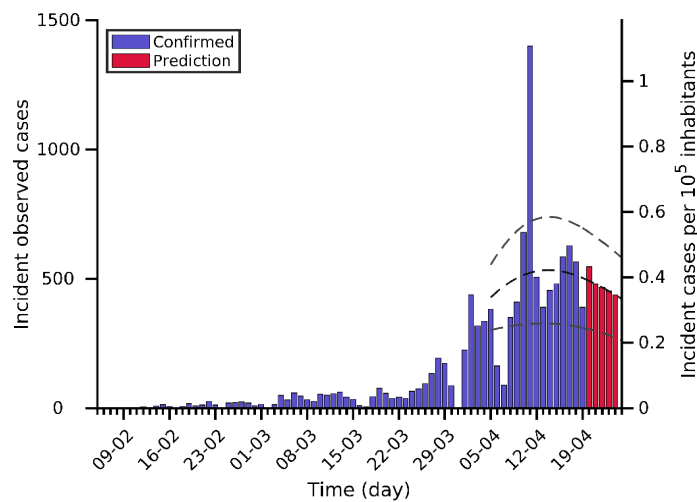
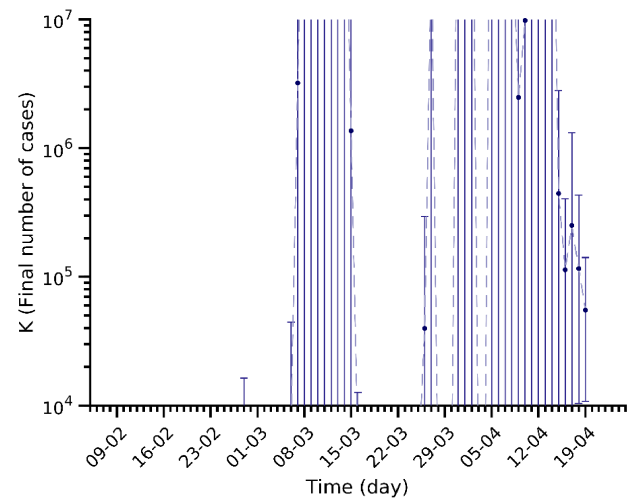
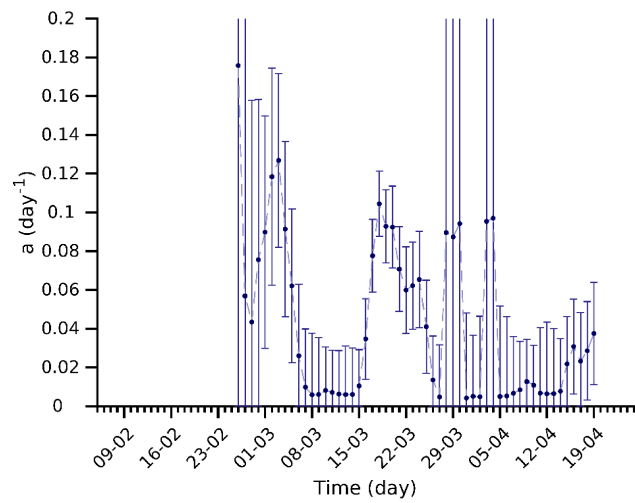
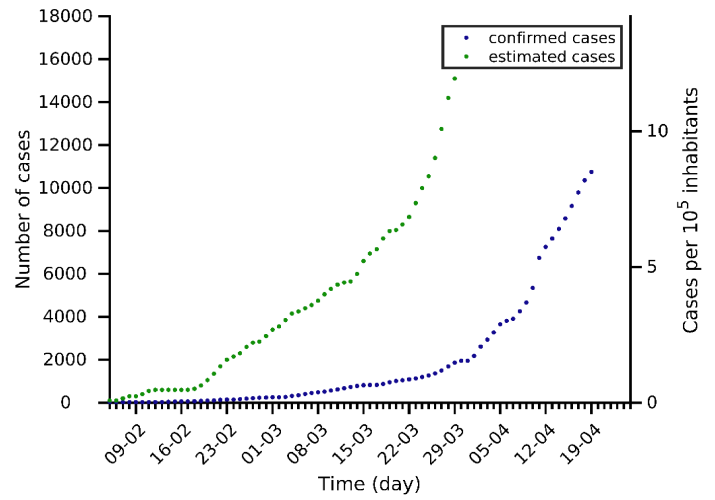
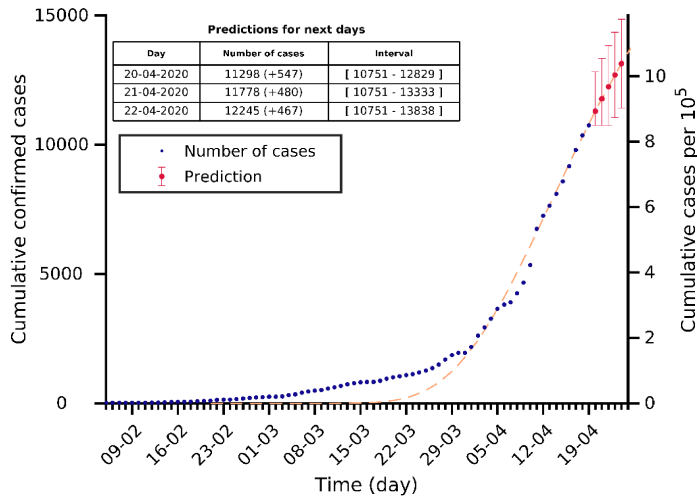
Peru 19-04-2020. Population: 33.0M. Current cumulated incidence: 47/10⁵



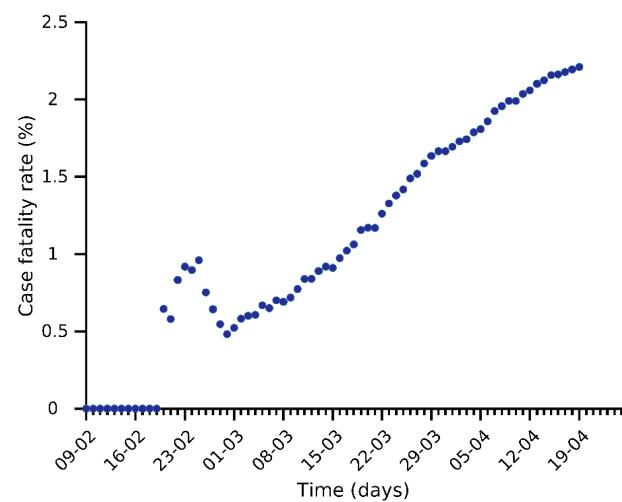
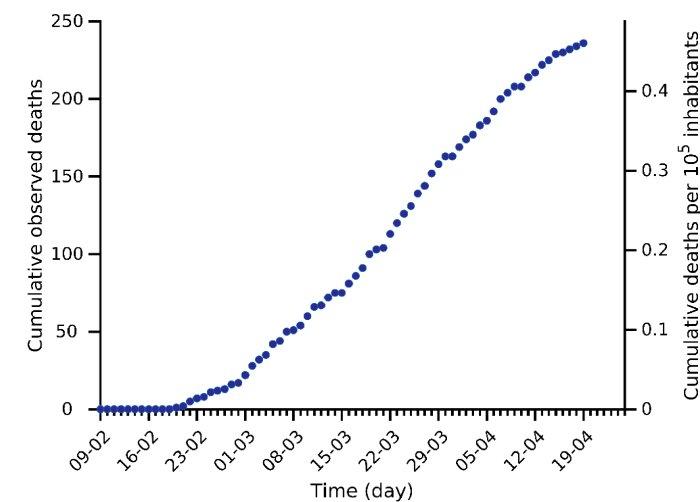
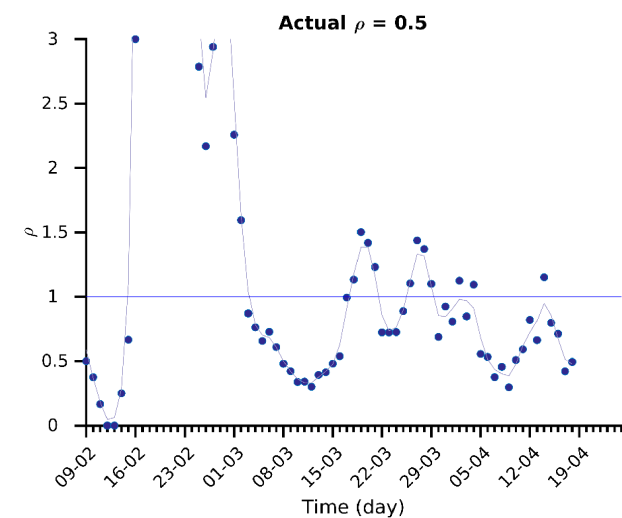
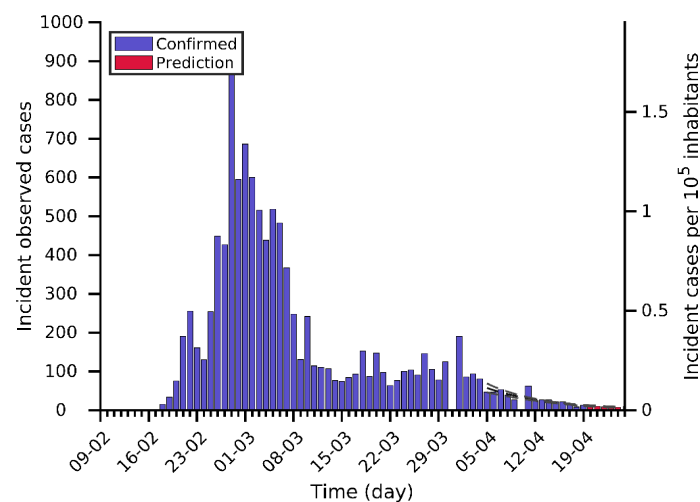
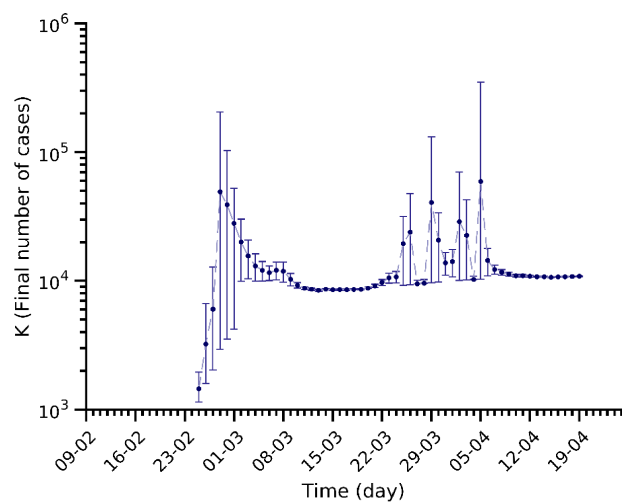
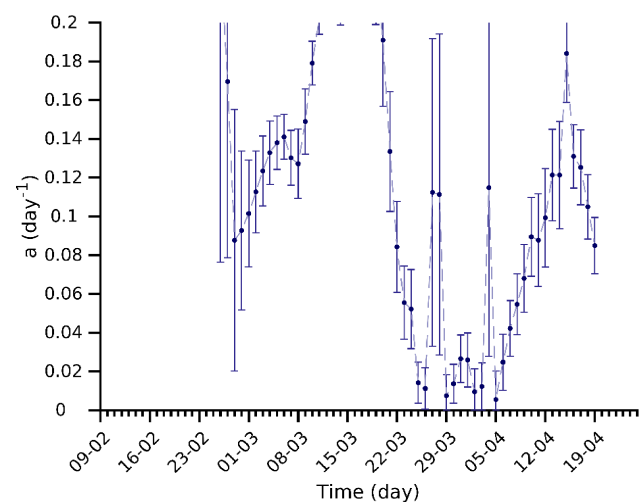
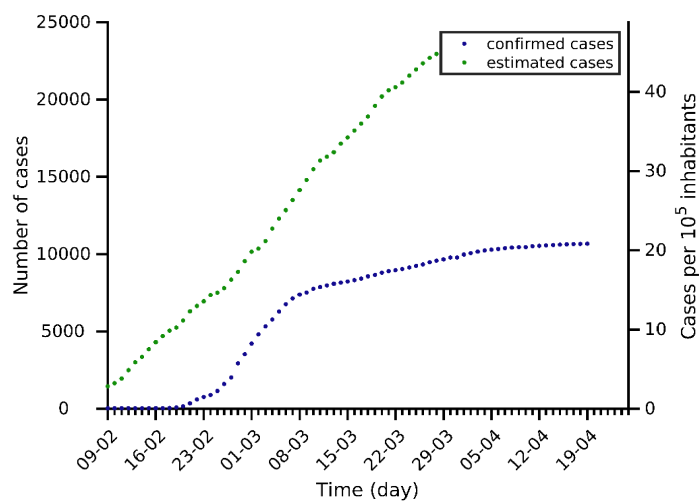
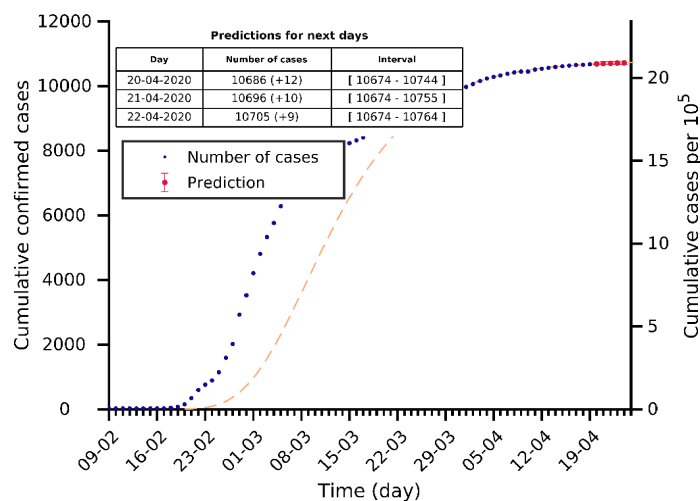
Israel 19-04-2020. Population: 8.7M. Current cumulated incidence: 156/10⁵



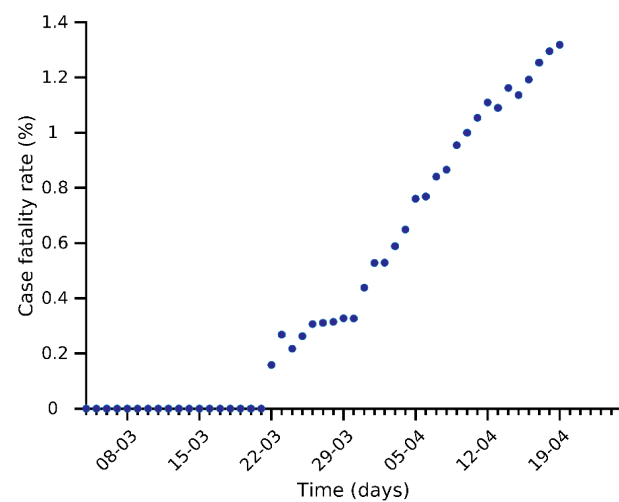
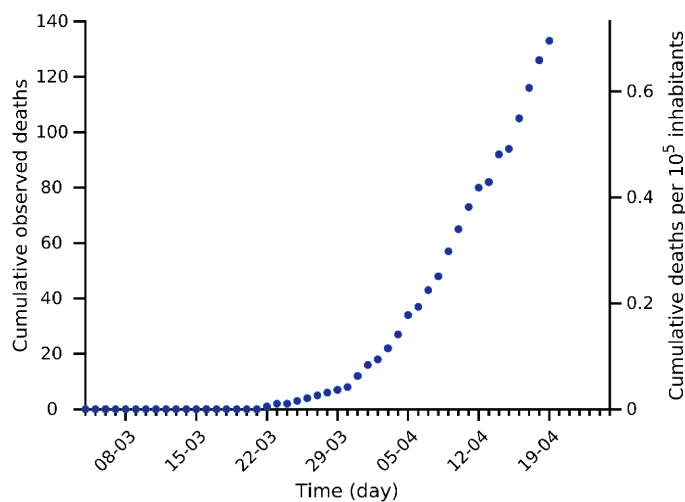
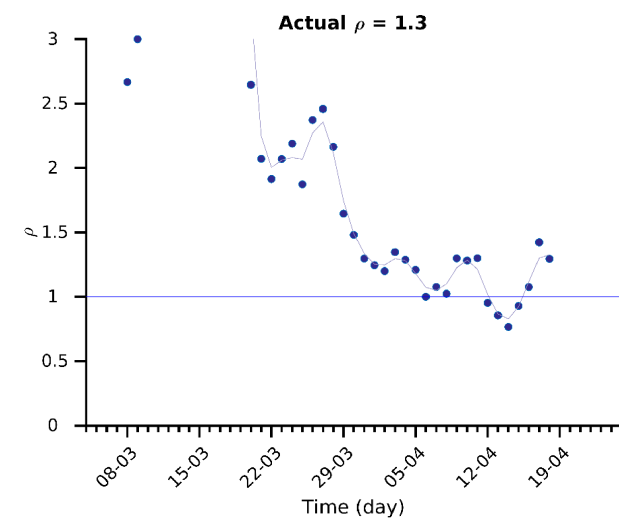
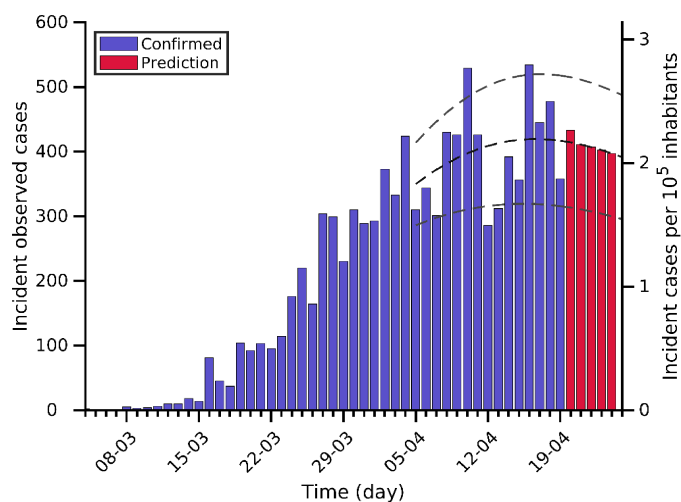
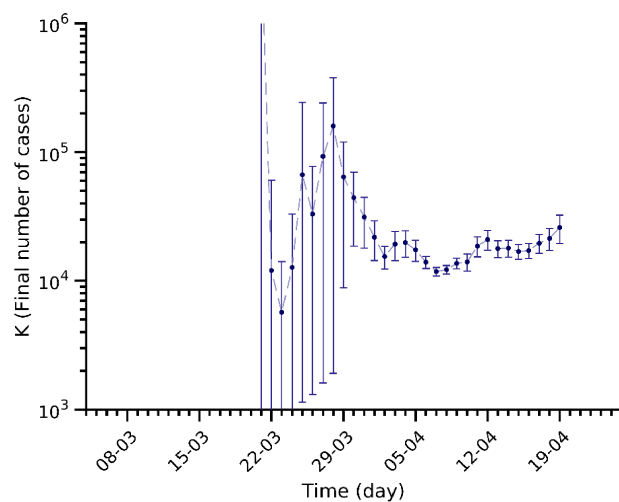
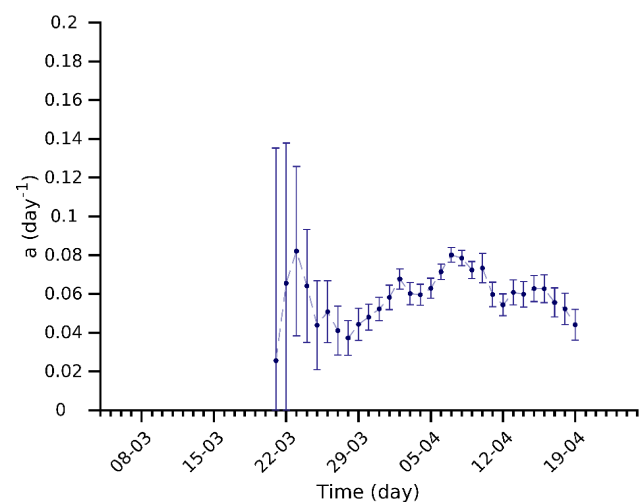
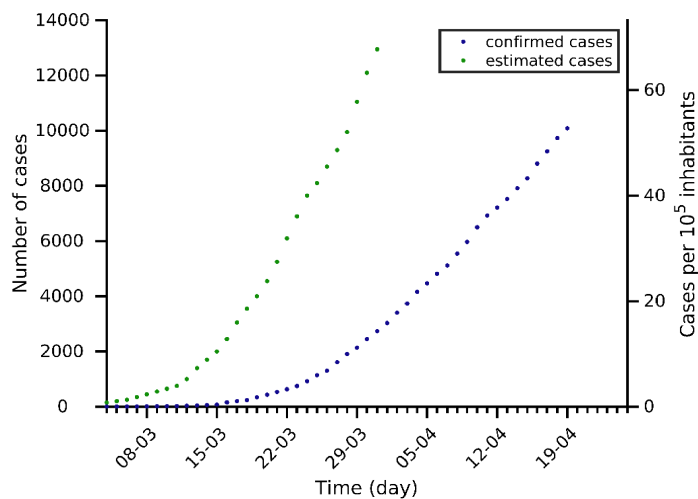
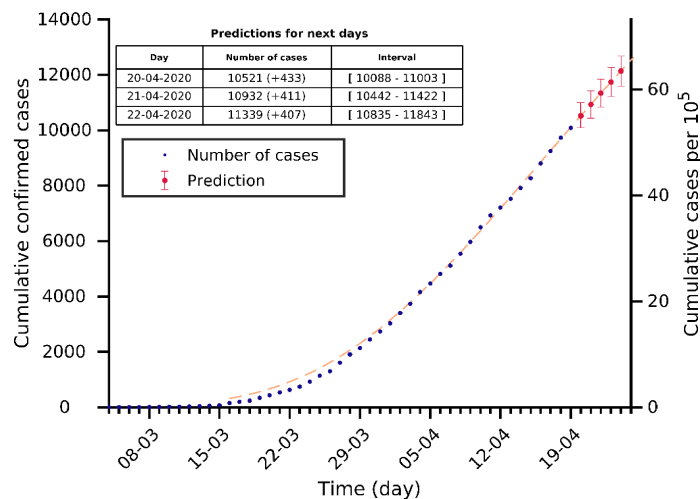
Japan 19-04-2020. Population: 126.5M. Current cumulated incidence: $9/10^5$



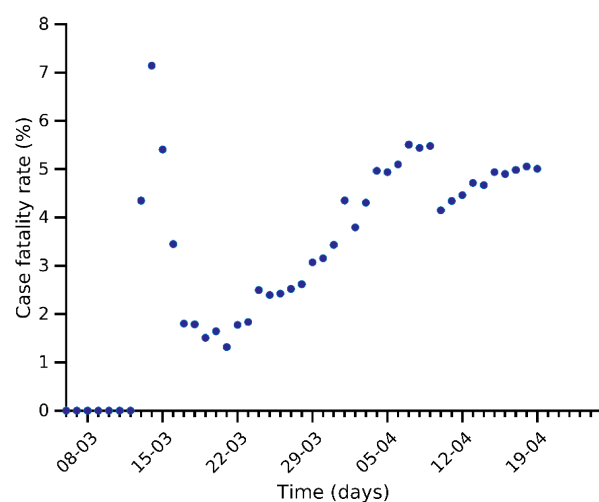
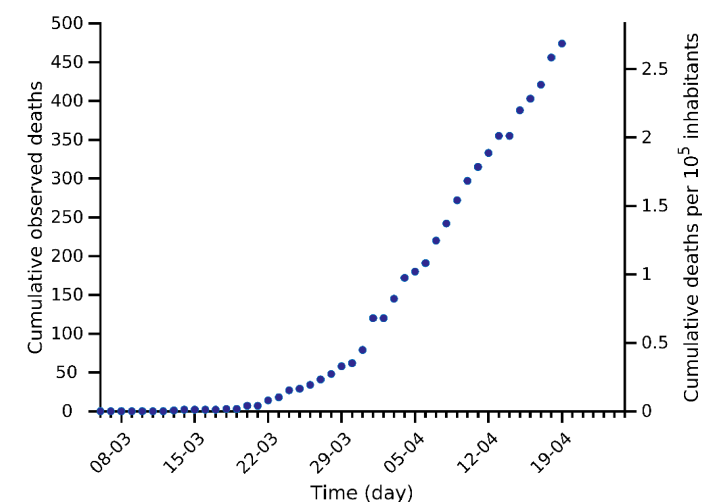
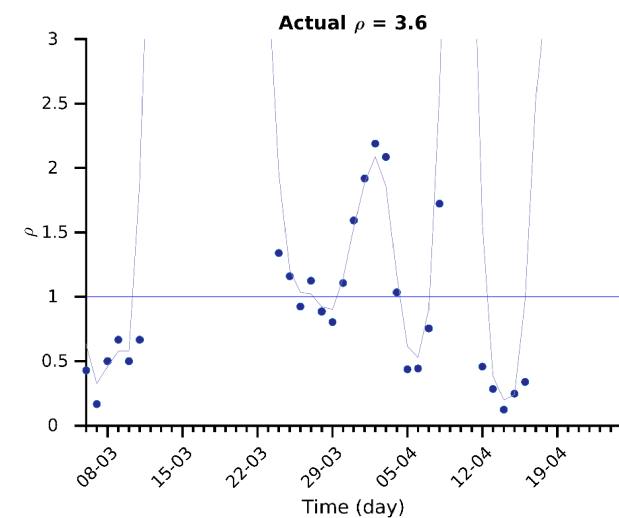
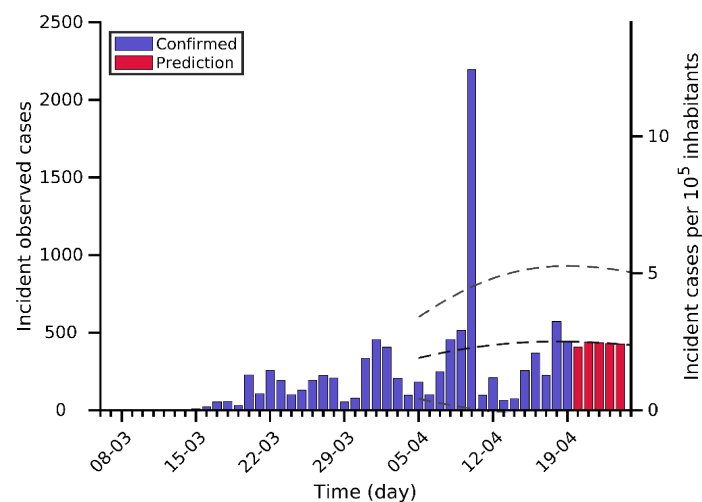
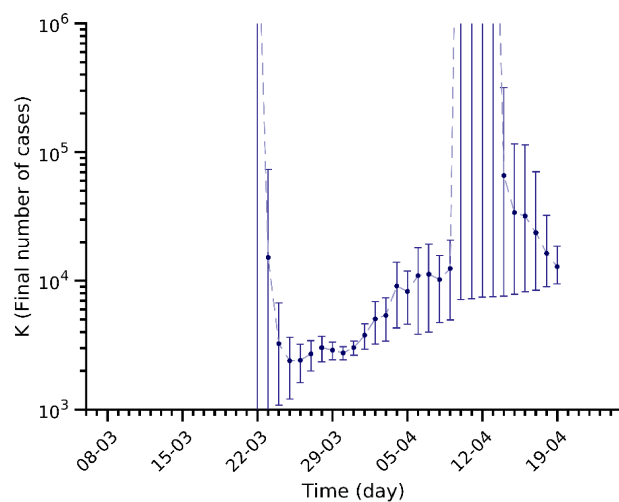
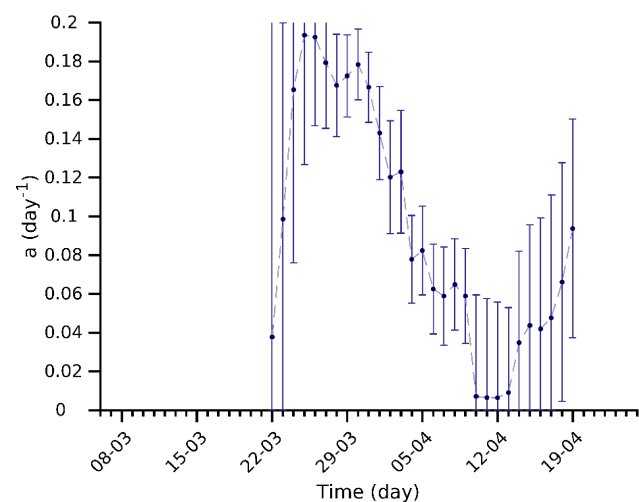
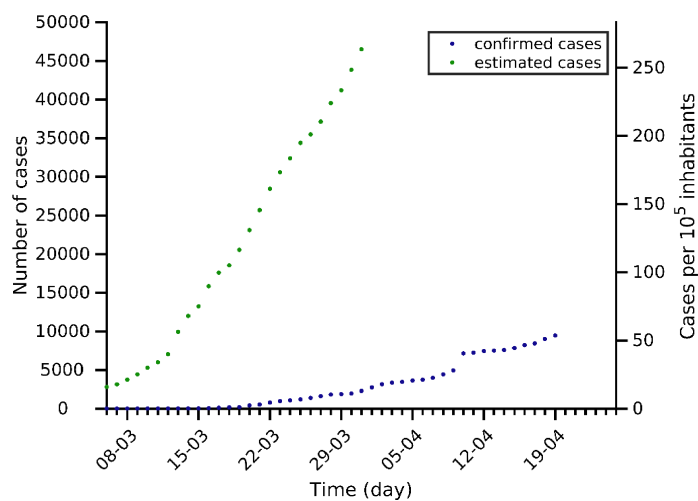
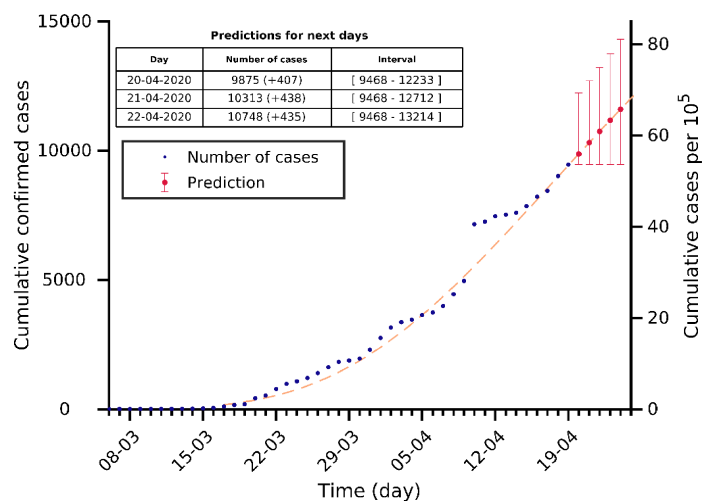
South Korea 19-04-2020. Population: 51.3M. Current cumulated incidence: 21/10⁵



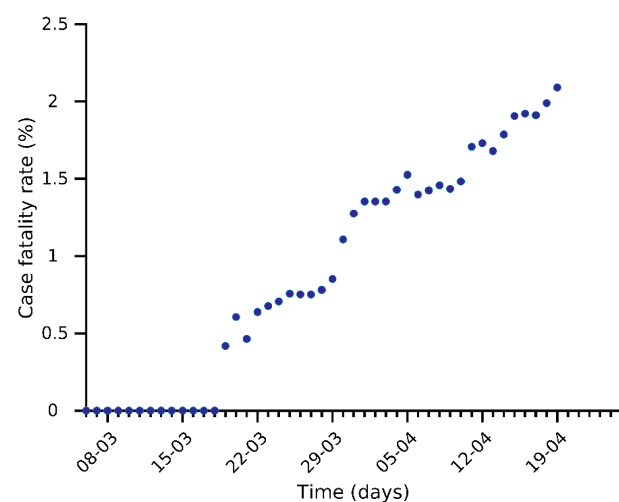
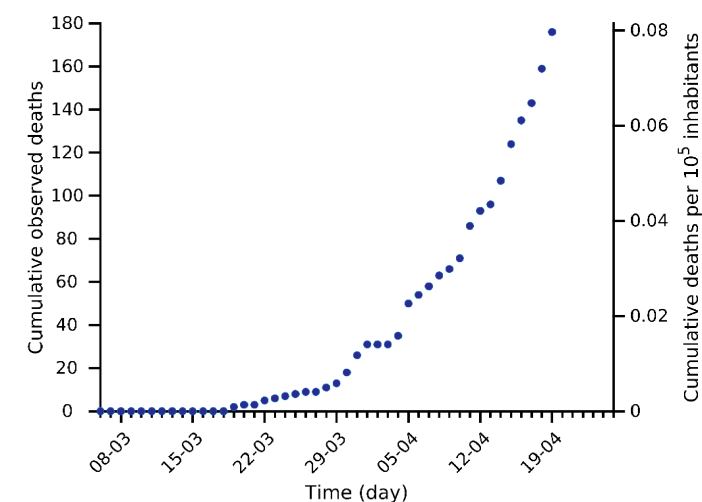
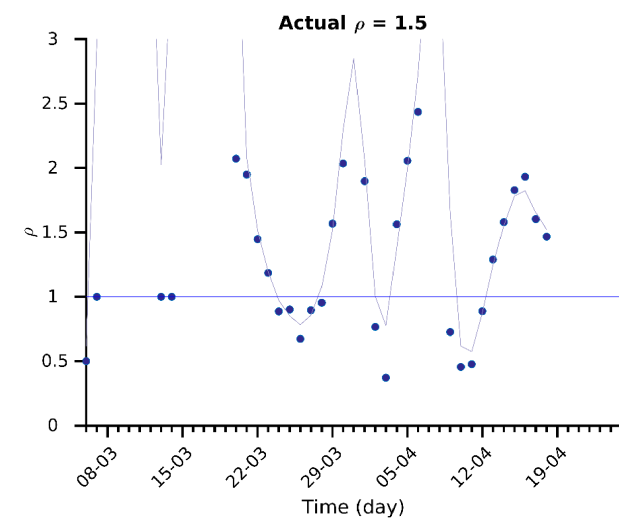
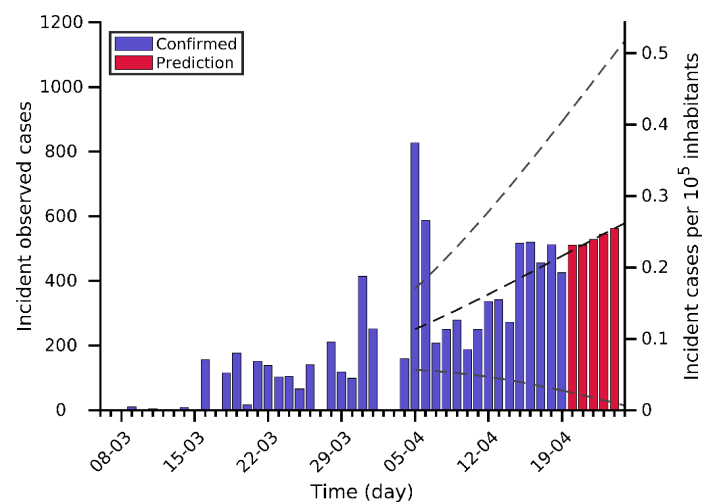
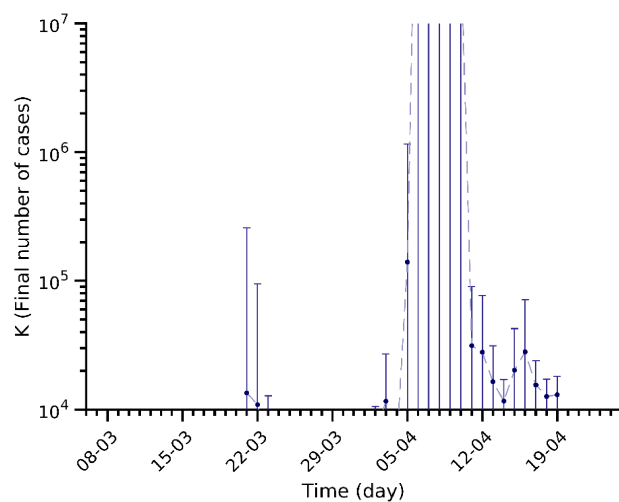
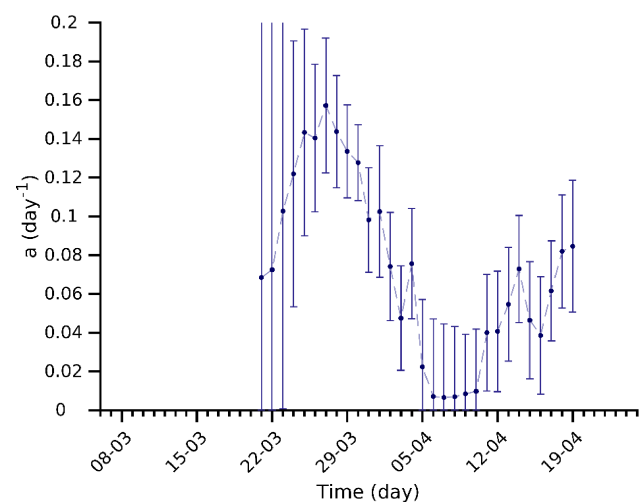
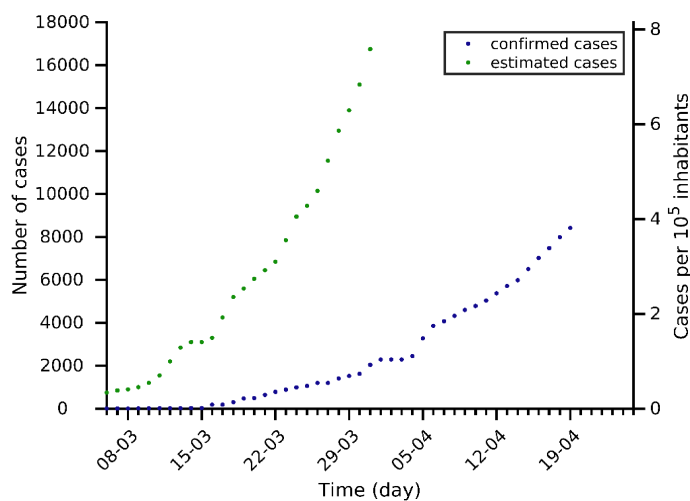
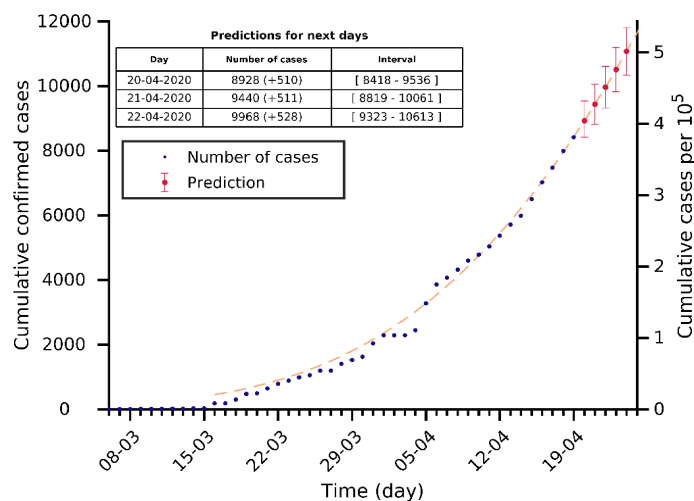
Chile 19-04-2020. Population: 19.1M. Current cumulated incidence: 53/10⁵



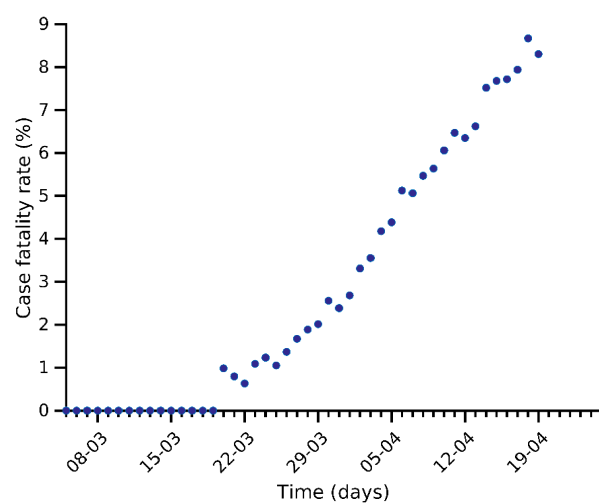
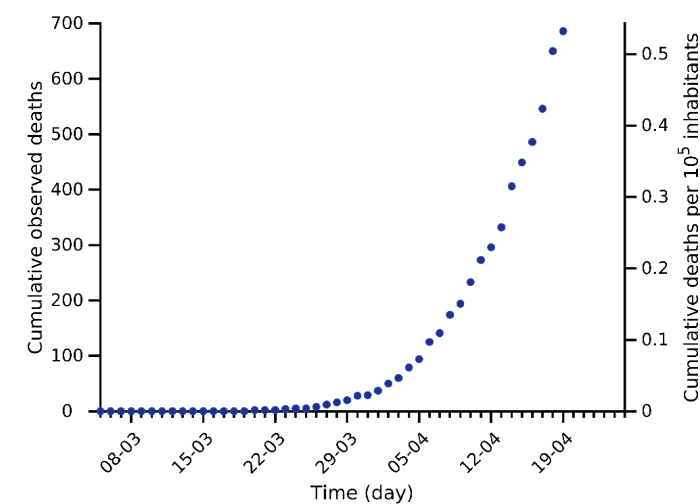
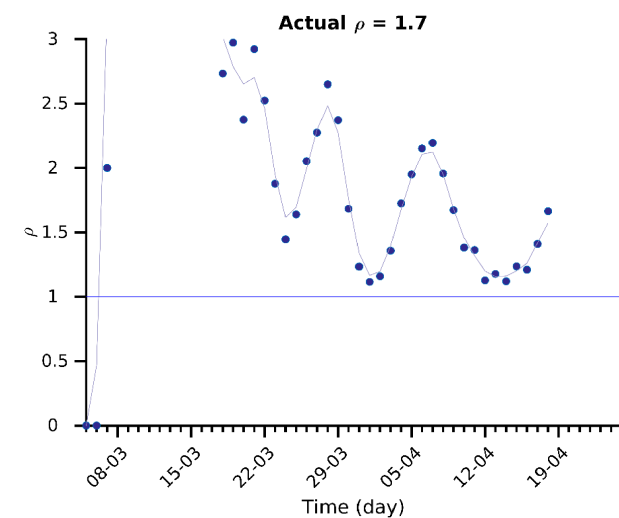
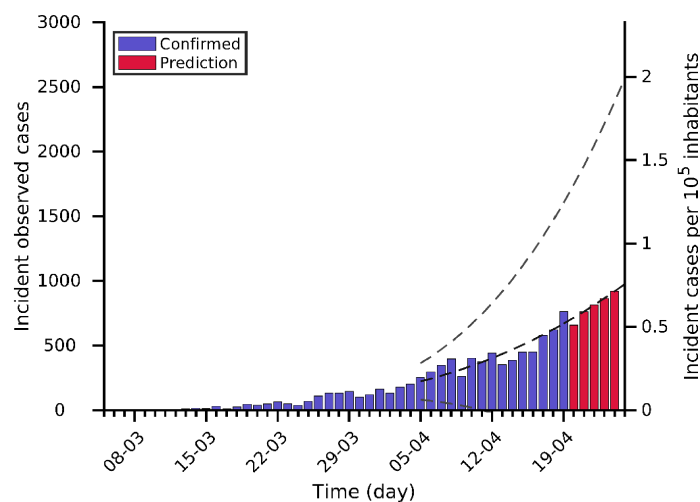
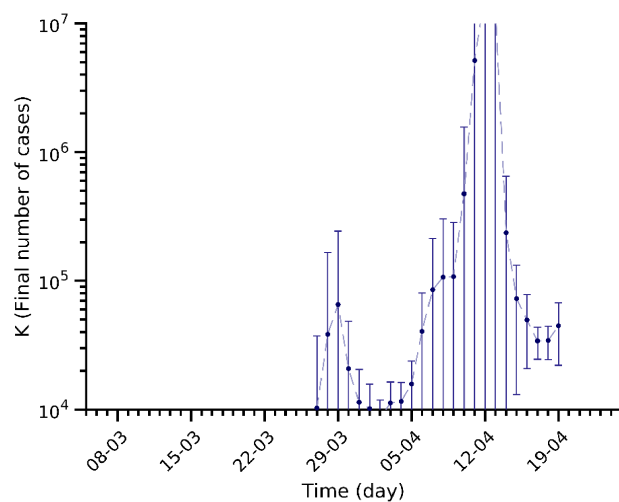
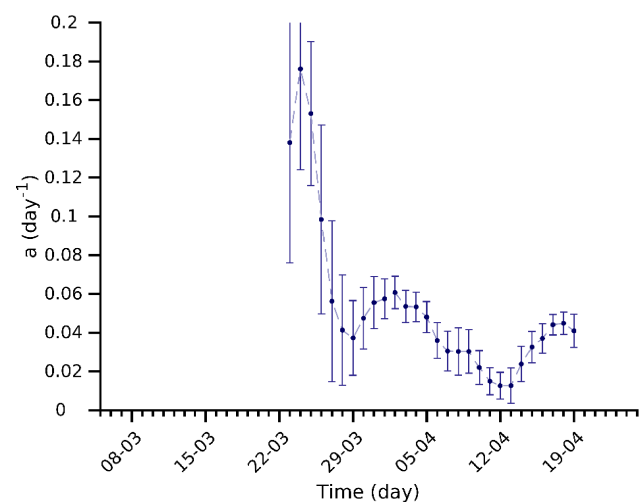
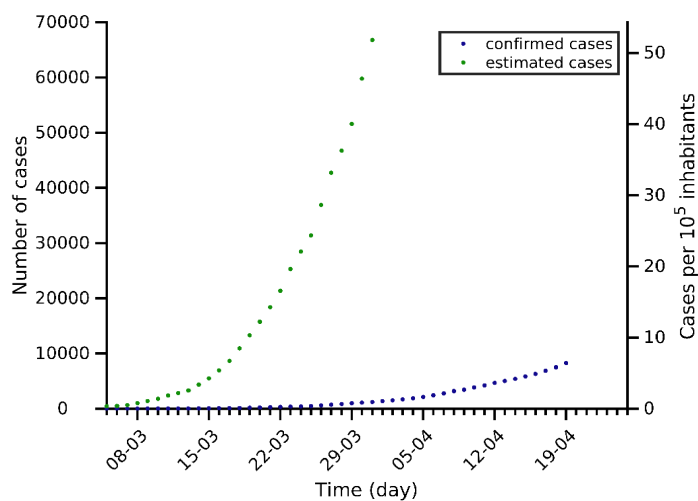
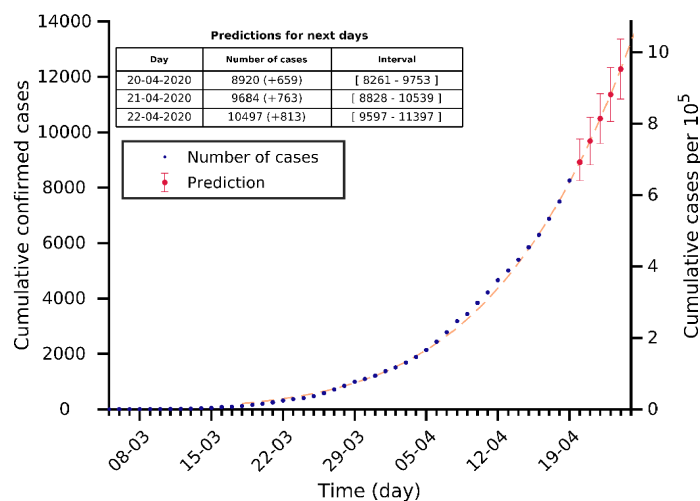
Ecuador 19-04-2020. Population: 17.6M. Current cumulated incidence: 54/10⁵



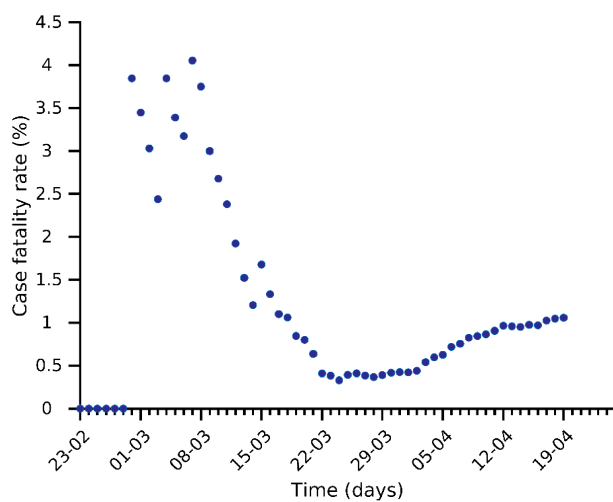
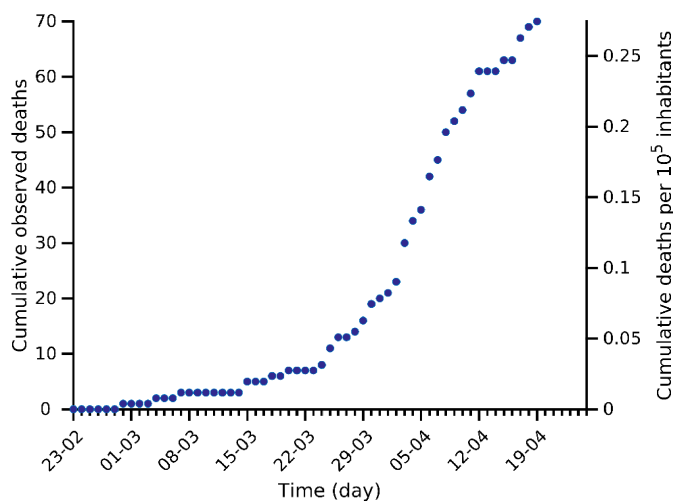
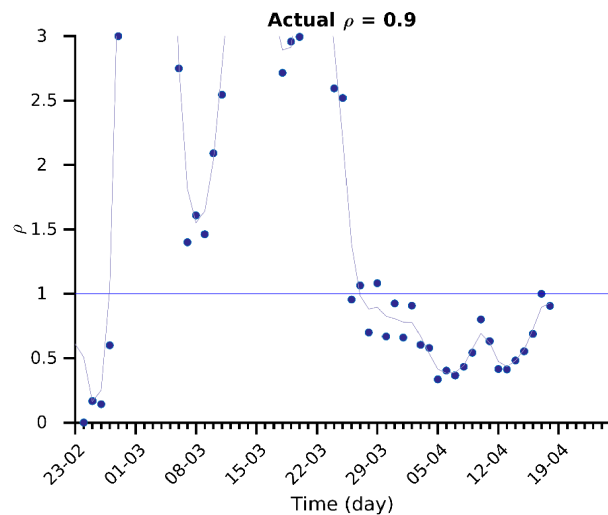
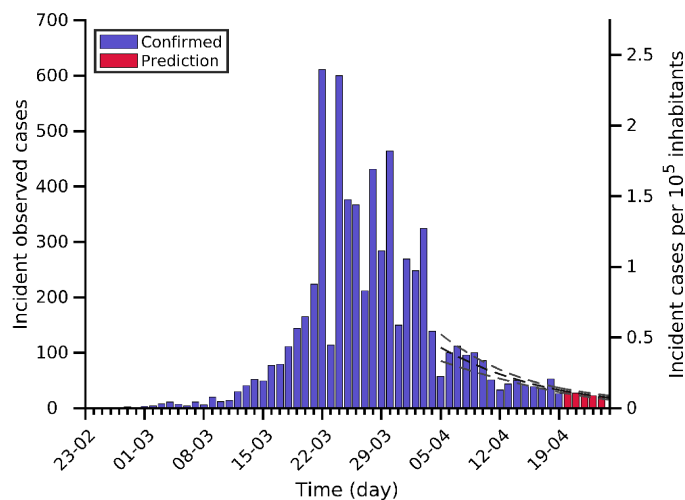
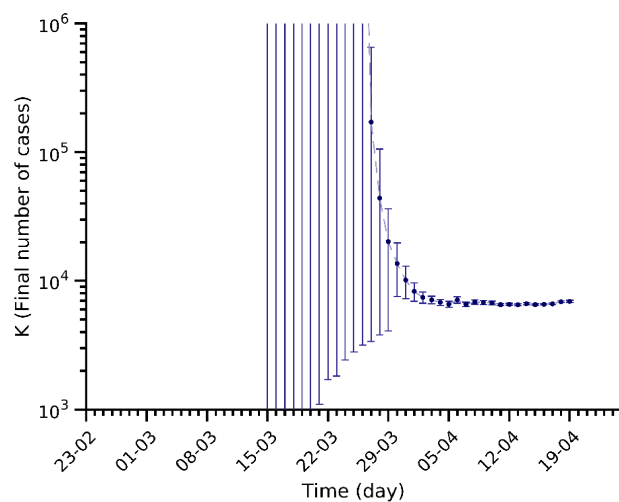
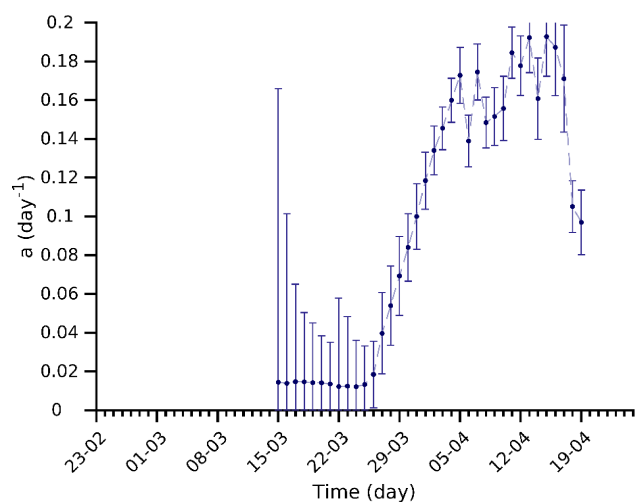
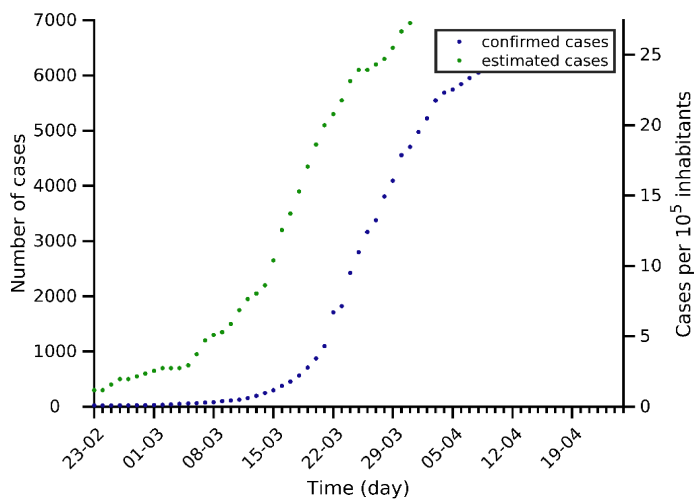
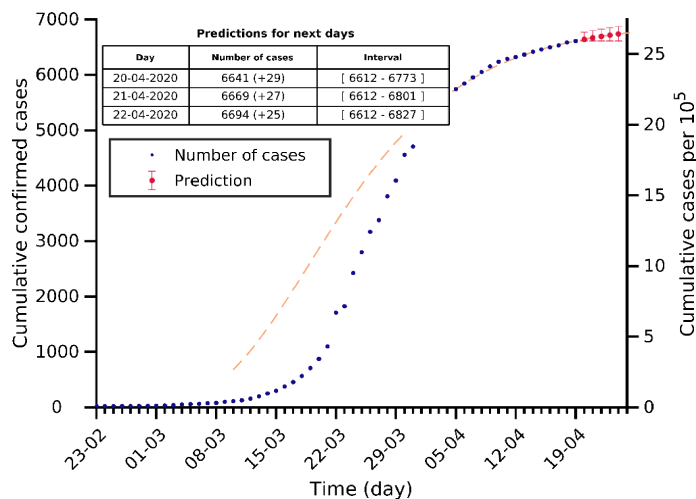
Pakistan 19-04-2020. Population: 220.9M. Current cumulated incidence: 4/10⁵



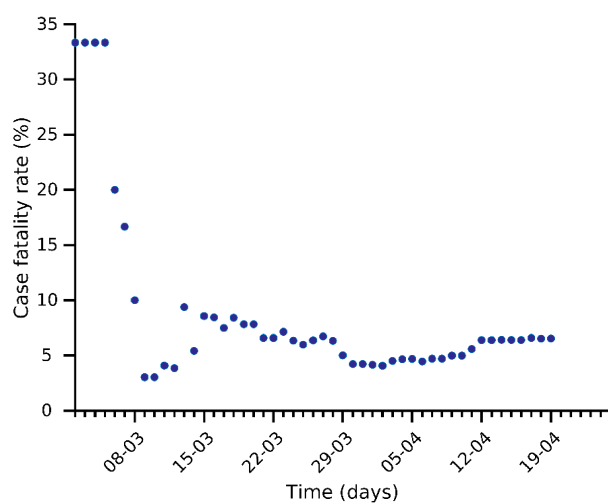
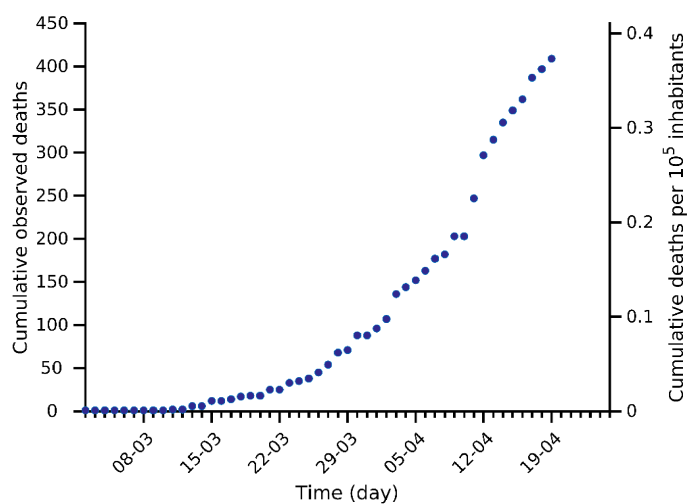
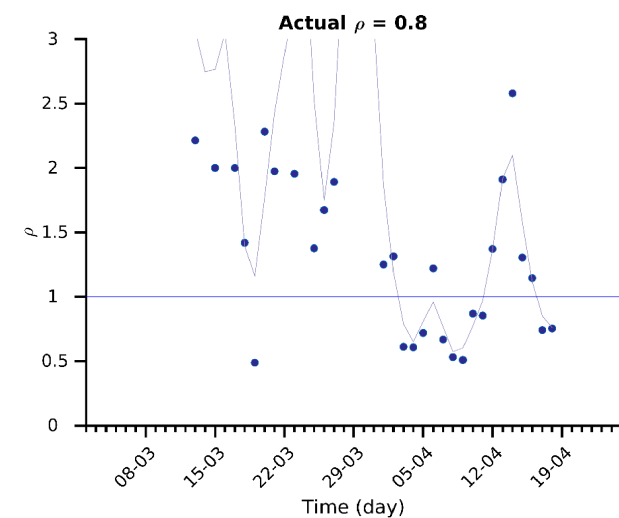
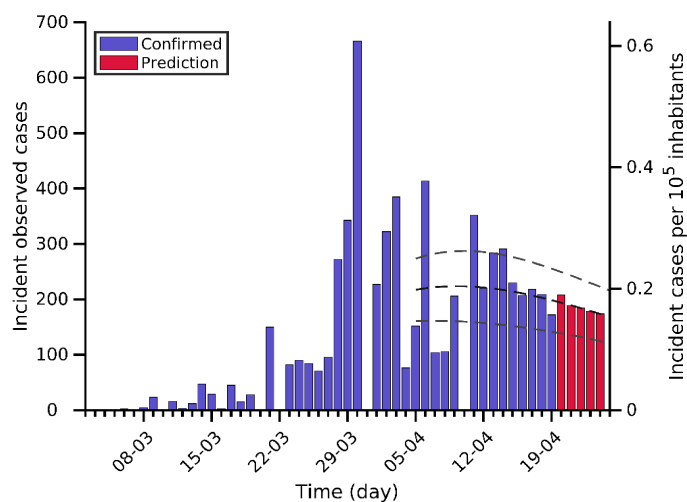
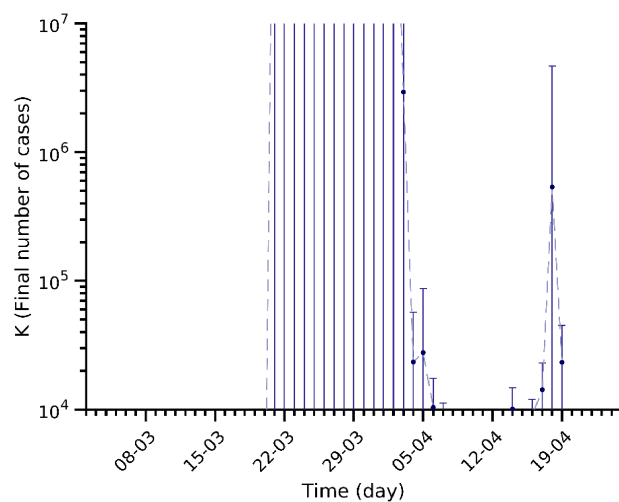
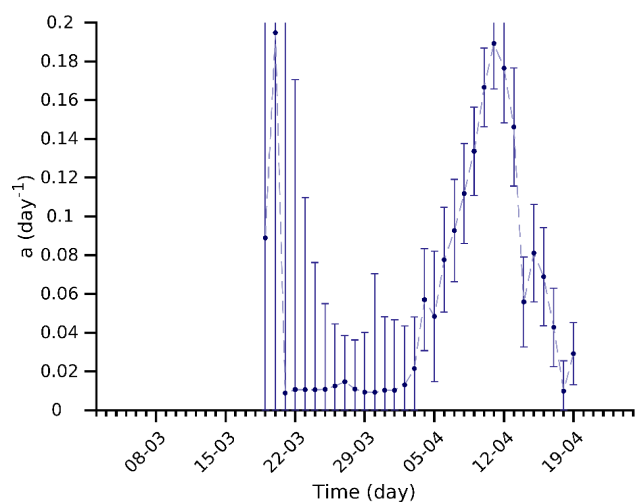
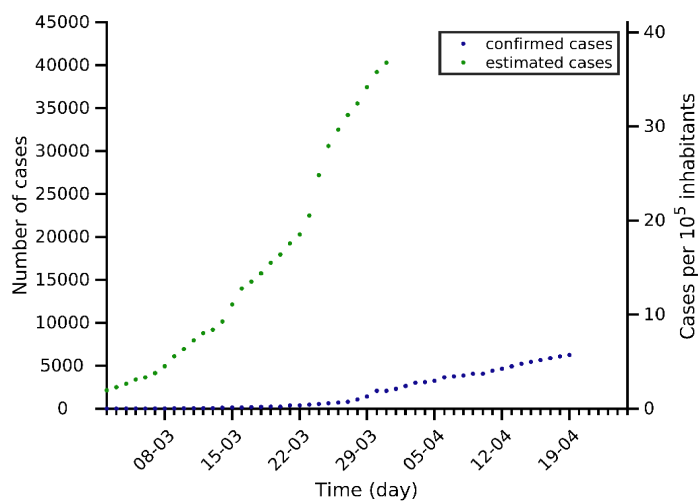
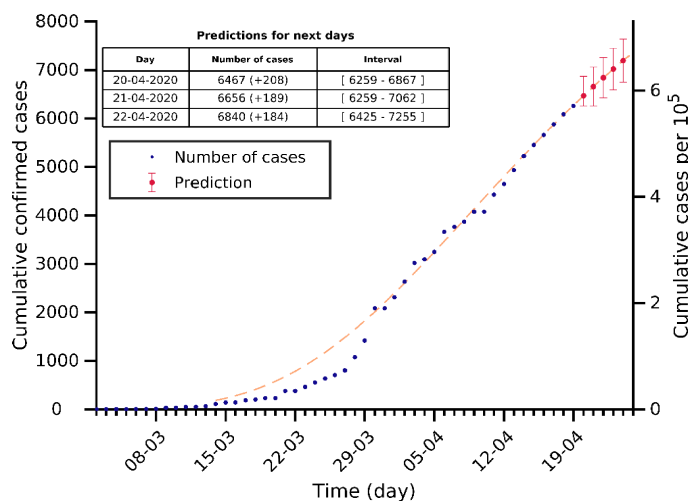
Mexico 19-04-2020. Population: 128.9M. Current cumulated incidence: $6/10^5$



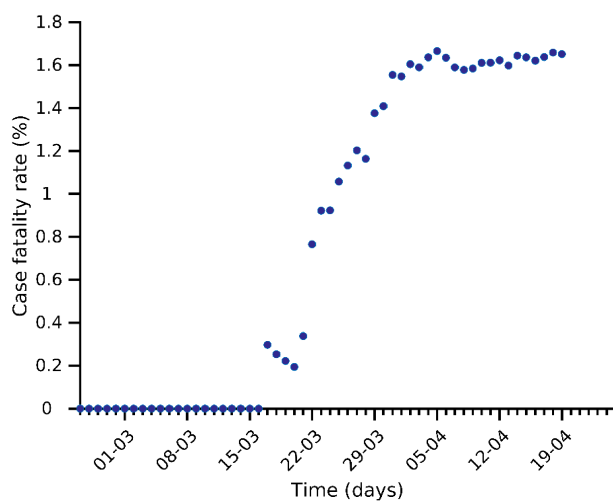
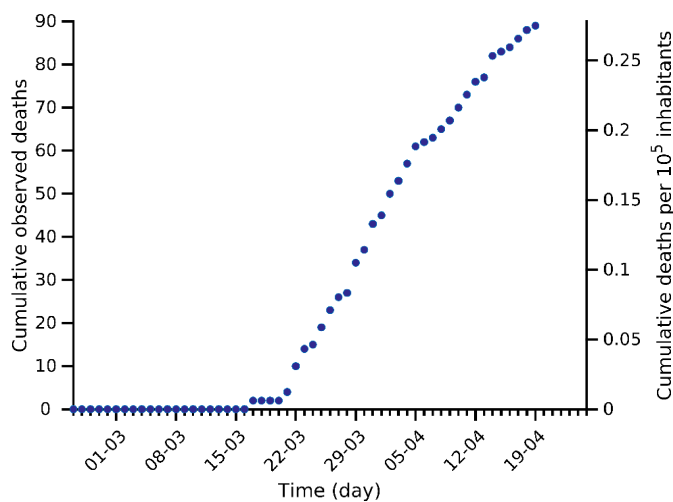
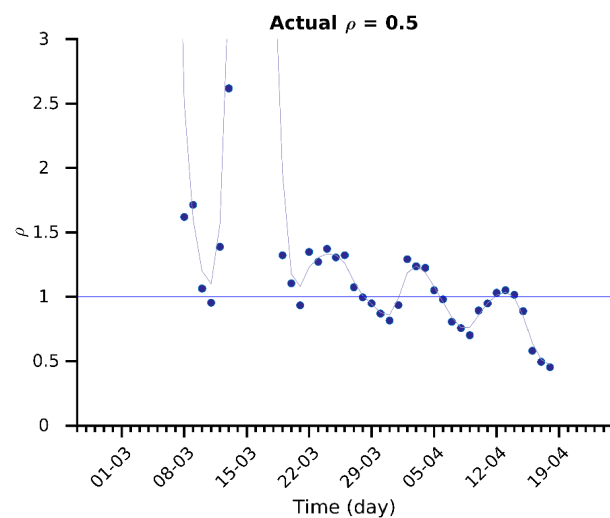
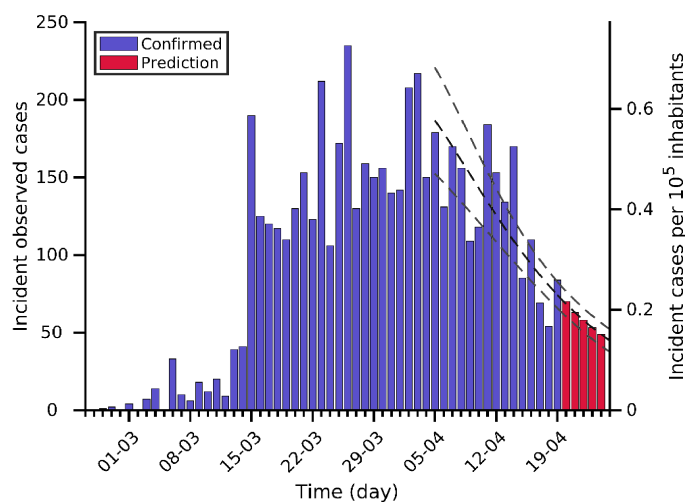
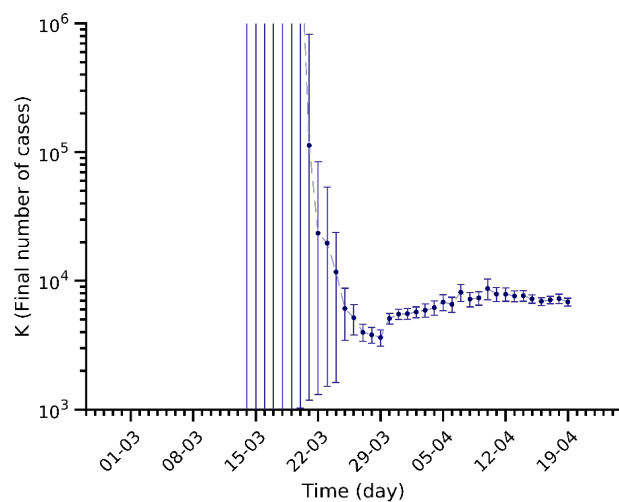
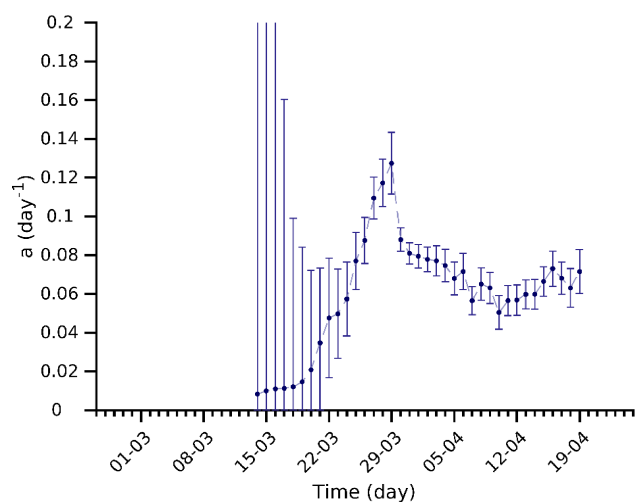
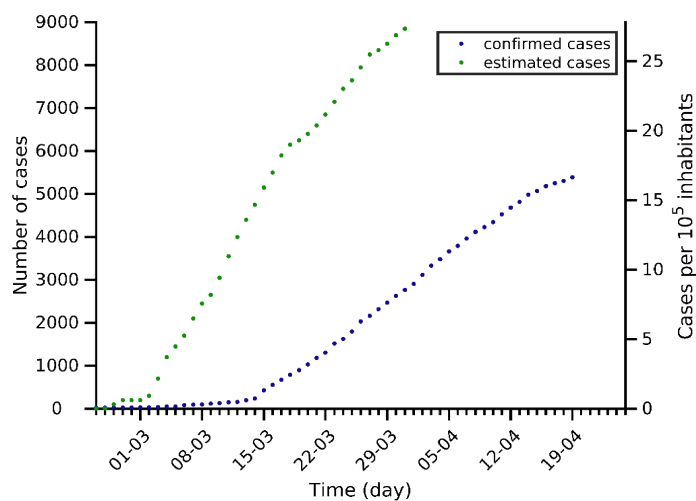
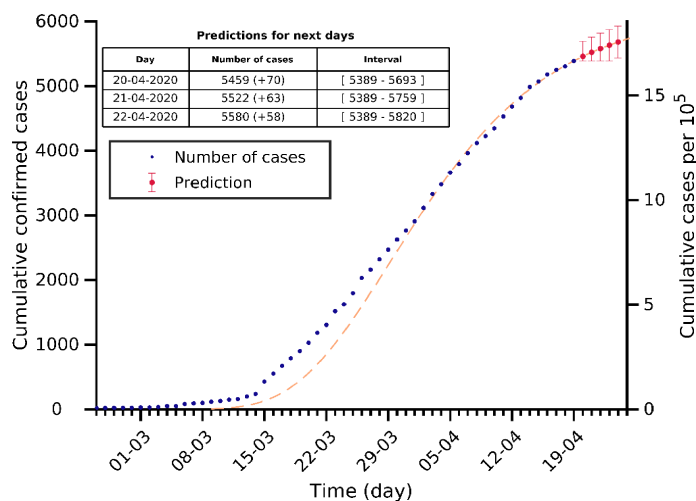
Australia 19-04-2020. Population: 25.5M. Current cumulated incidence: 26/10⁵



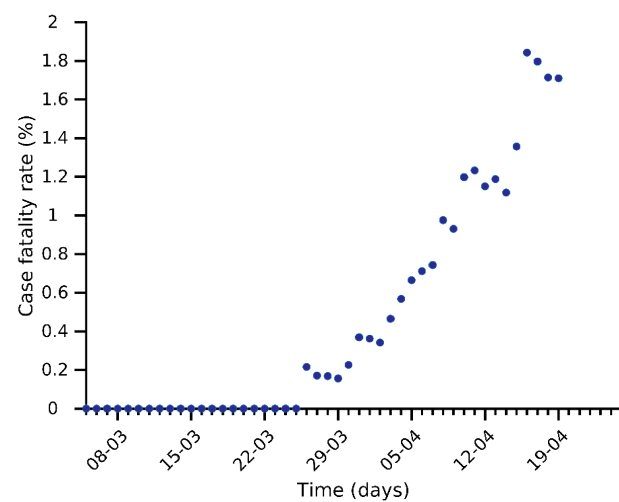
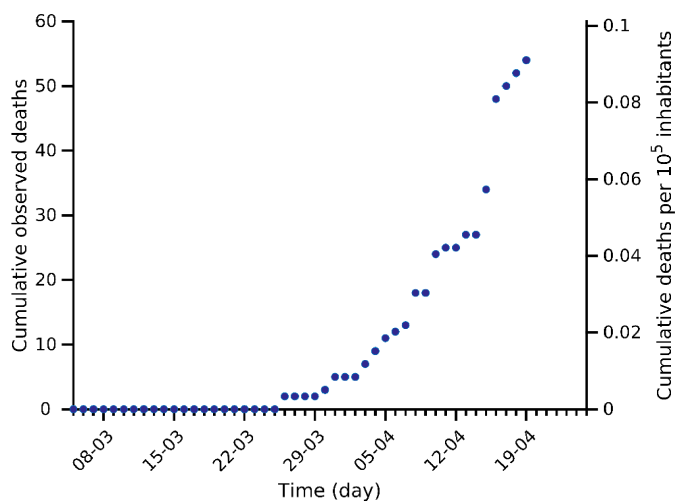
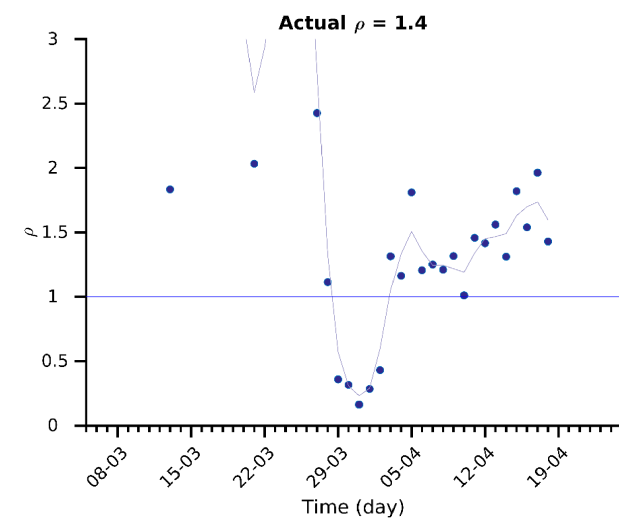
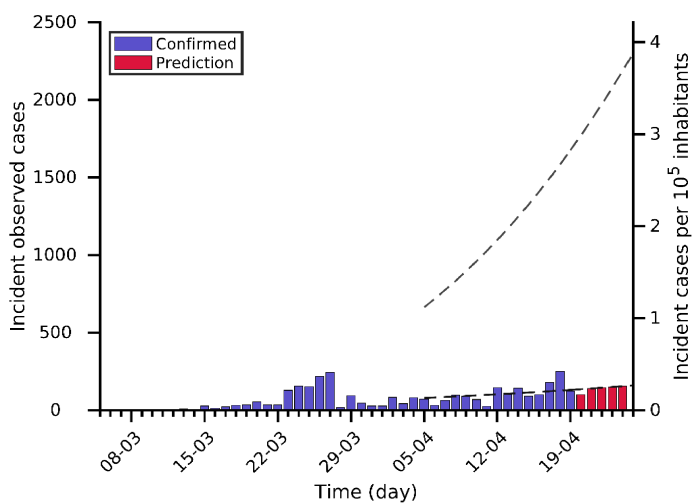
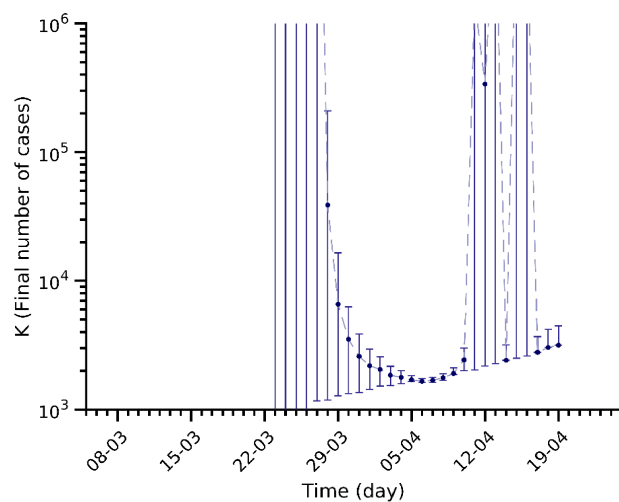
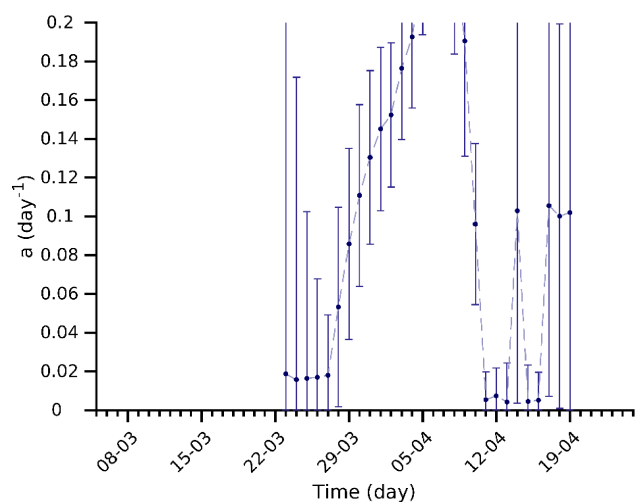
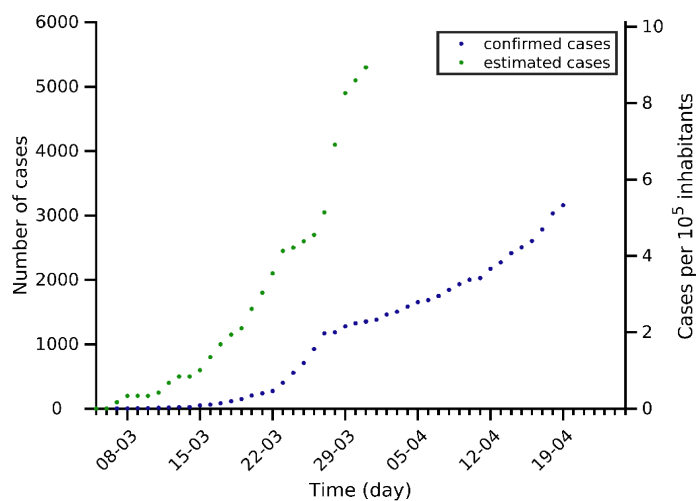
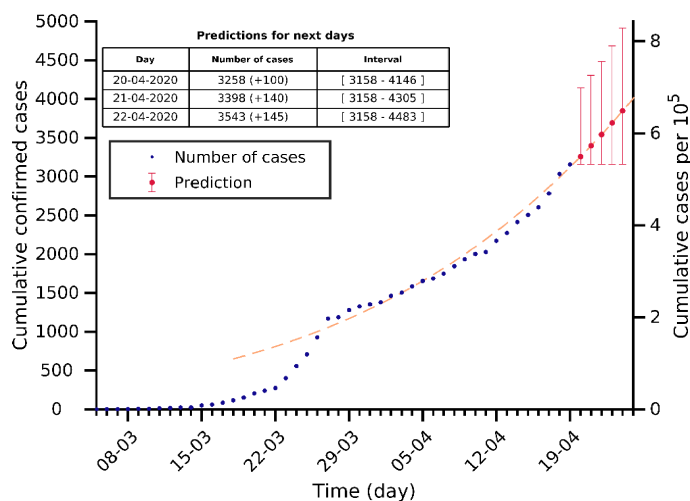
Philippines 19-04-2020. Population: 109.6M. Current cumulated incidence: 6/10⁵



Malaysia 19-04-2020. Population: 32.4M. Current cumulated incidence: 17/10⁵



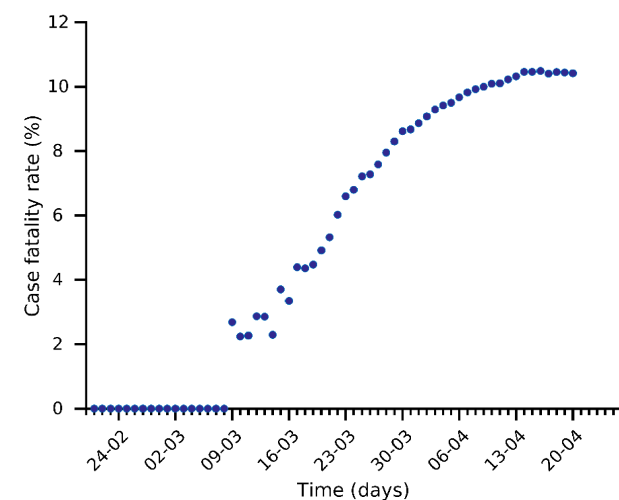
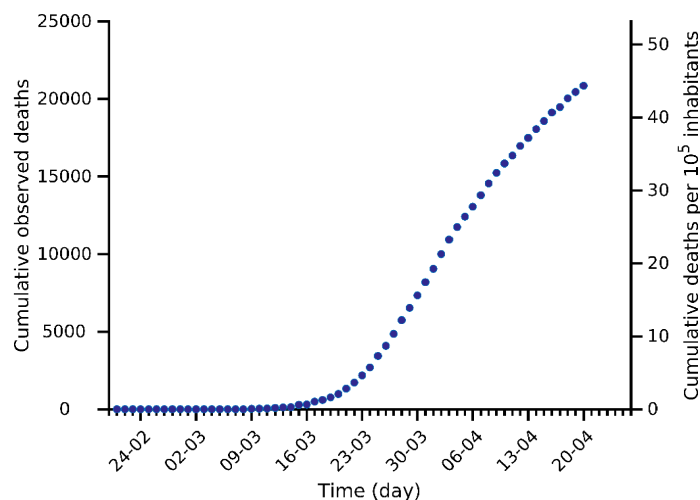
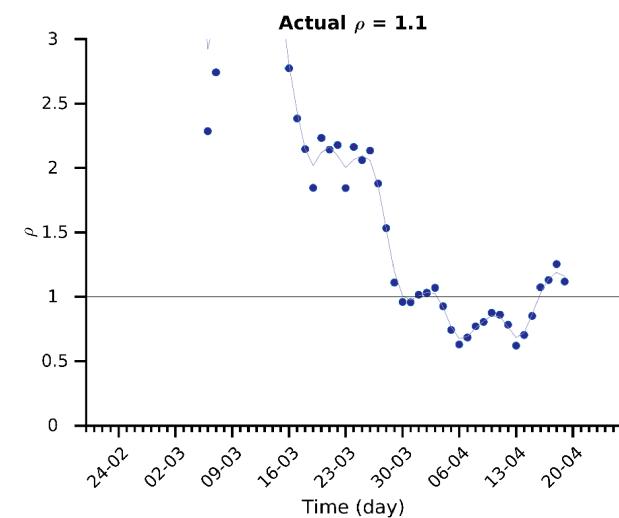
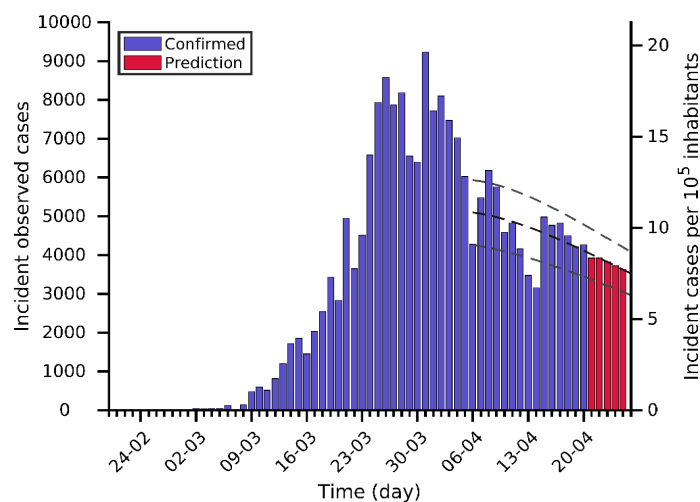
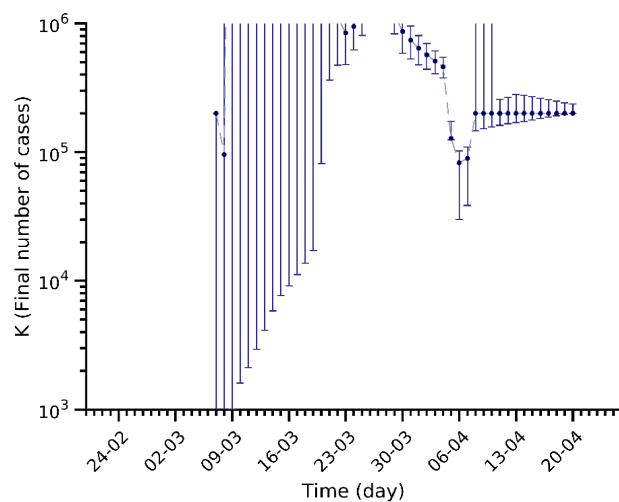
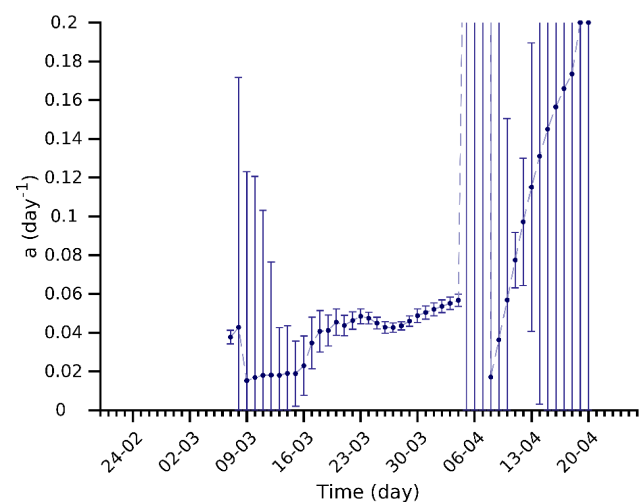
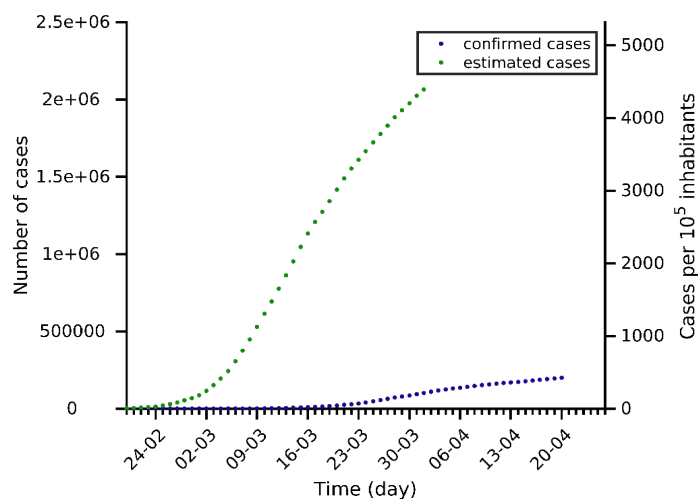
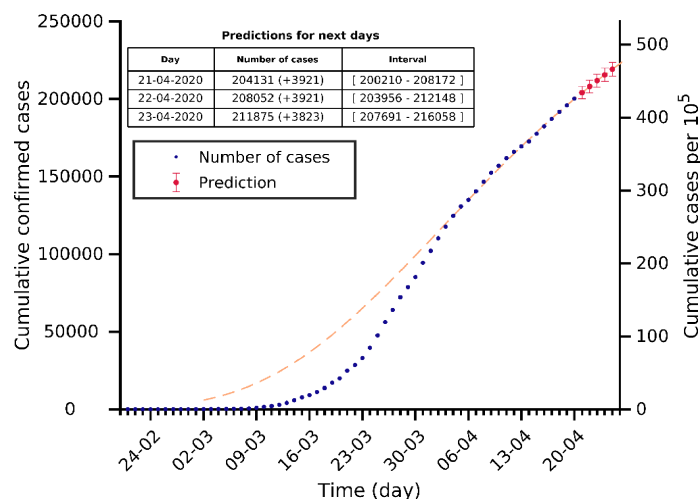
South Africa 19-04-2020. Population: 59.3M. Current cumulated incidence: 5/10⁵



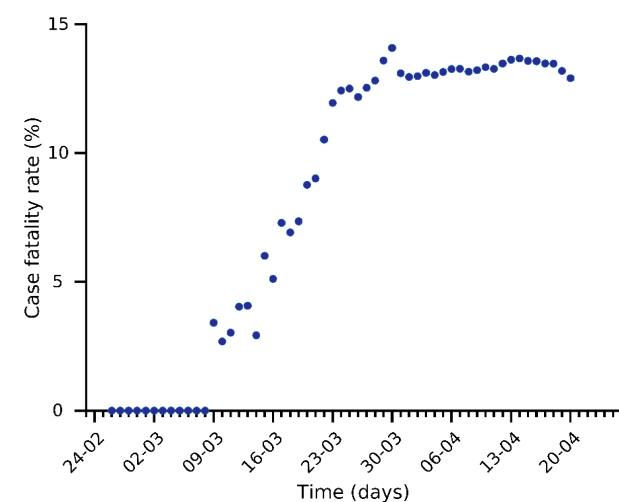
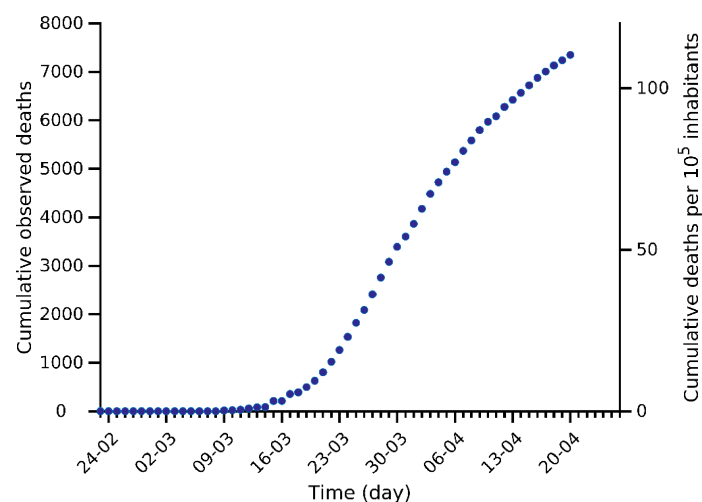
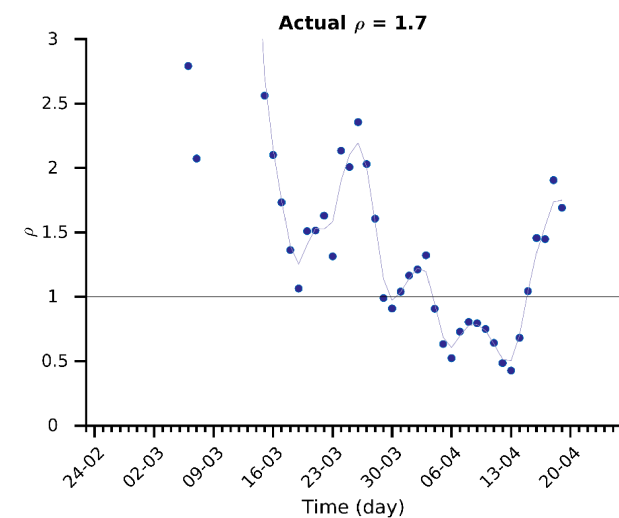
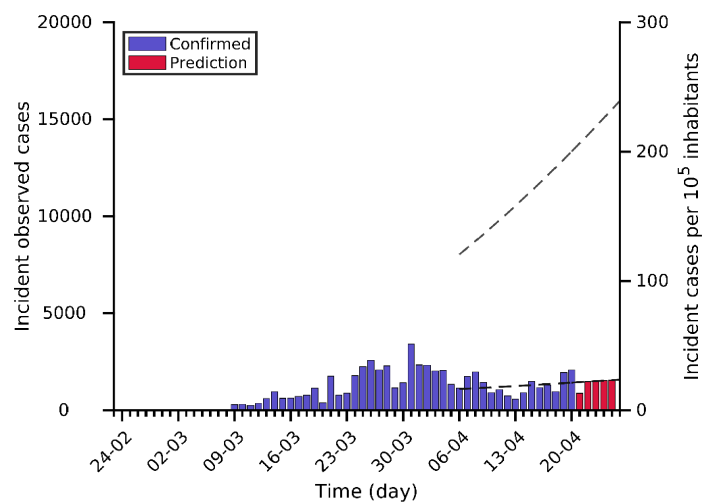
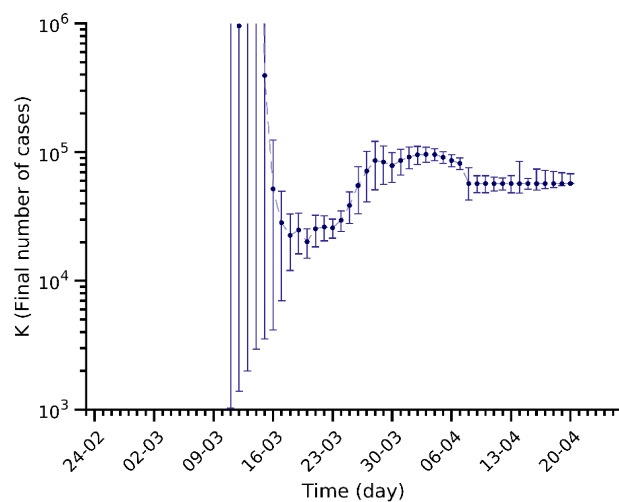
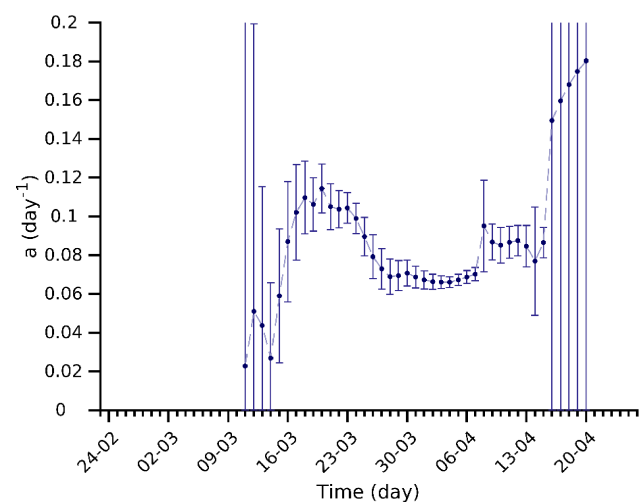
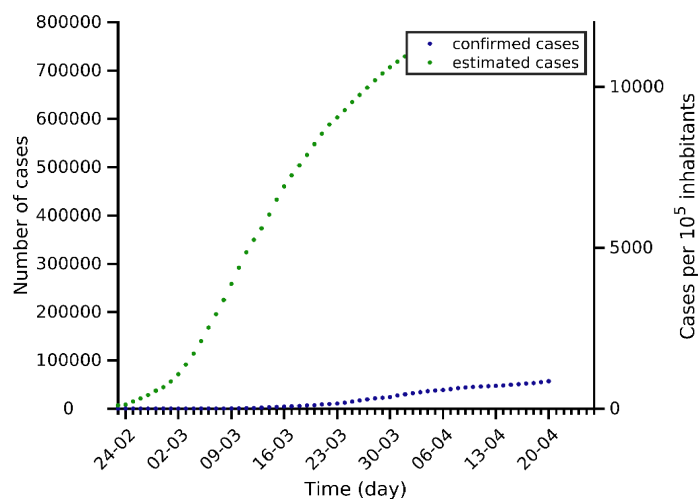
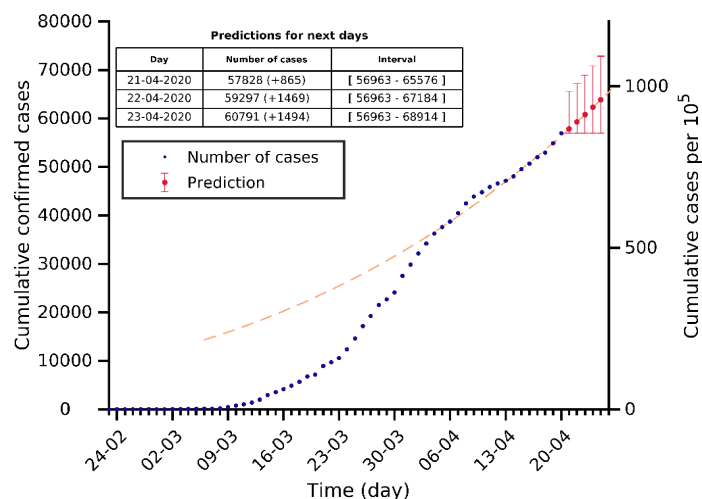
(3) Analysis and prediction of COVID-19 for Spain and its autonomous communities

Data obtained from <https://github.com/datadista/datasets/tree/master/COVID%2019> and
<https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm>

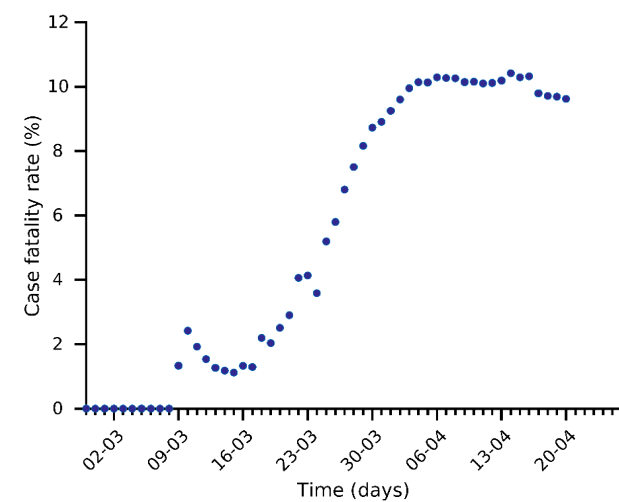
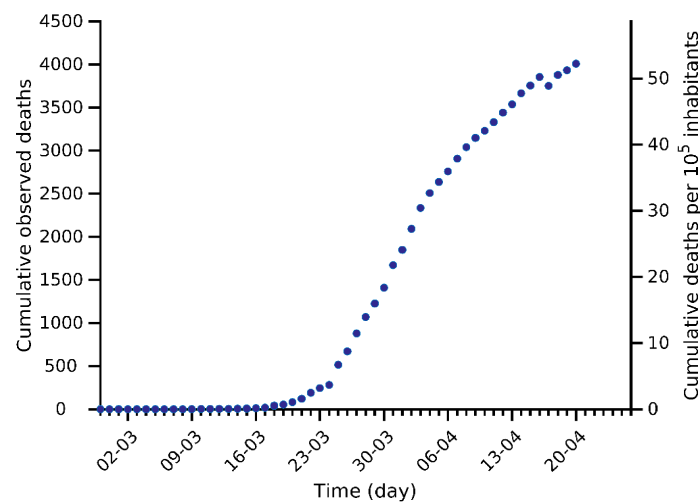
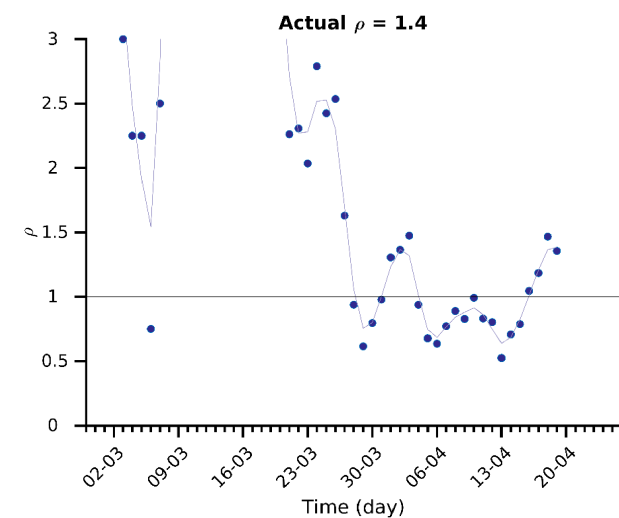
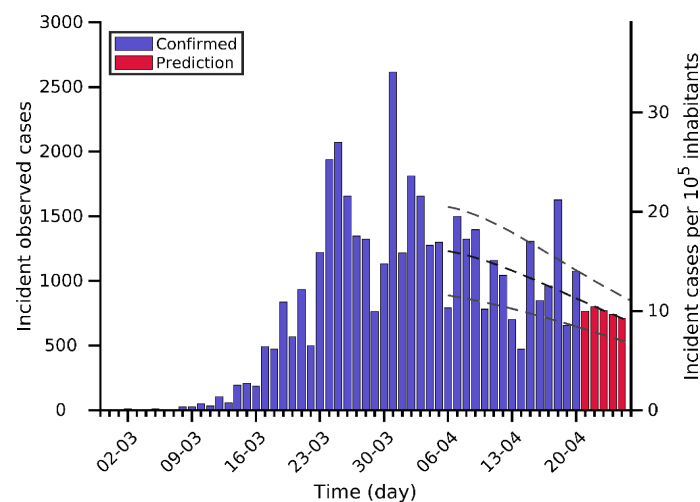
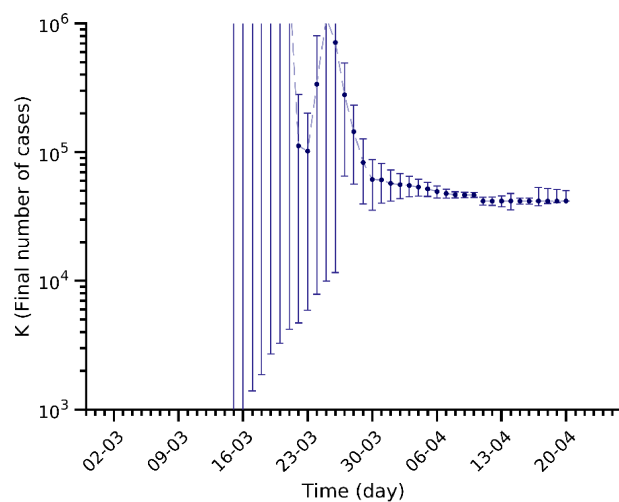
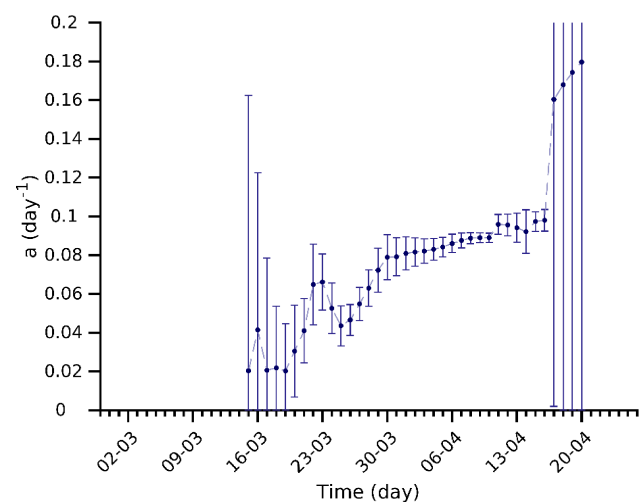
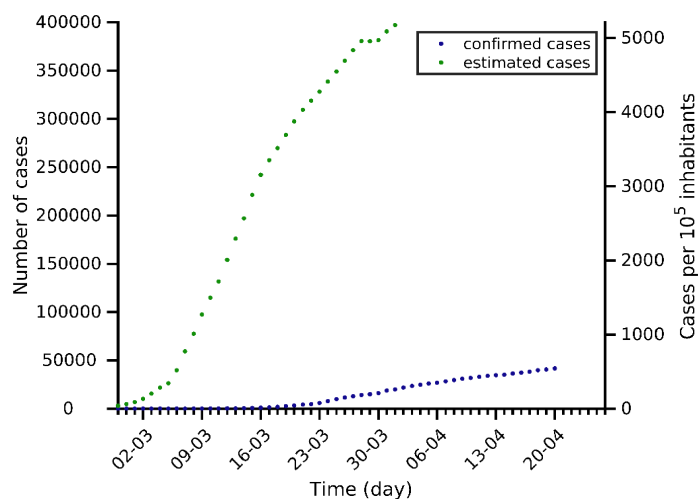
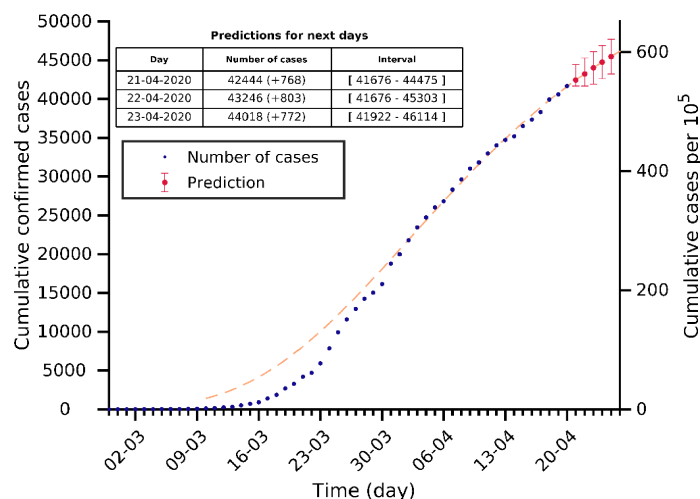
Spain 20-04-2020. Population: 47.0M. Current cumulated incidence: 426/10⁵



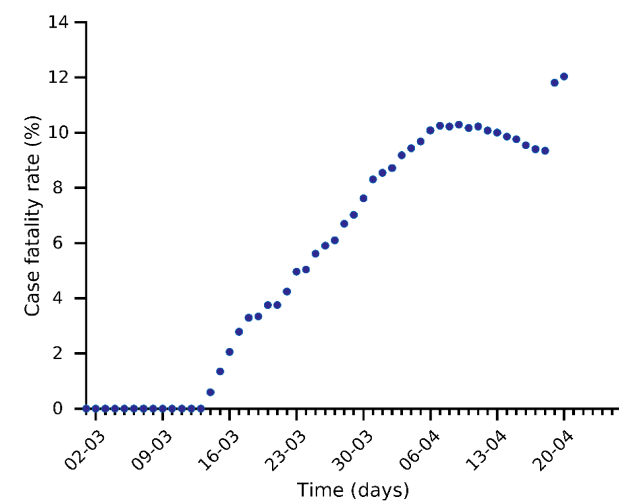
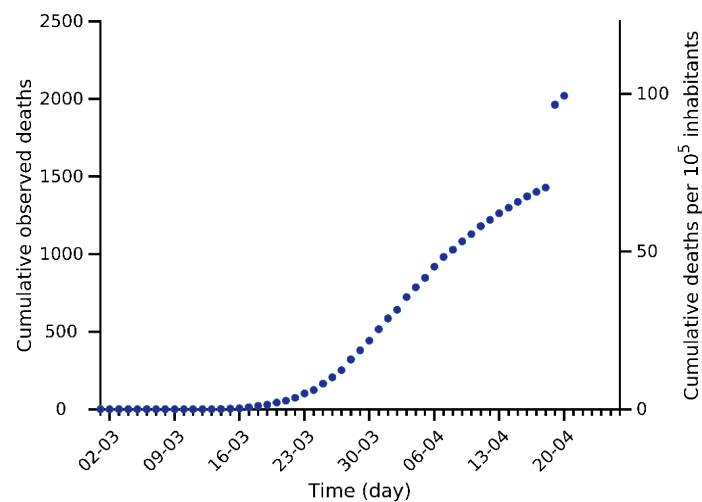
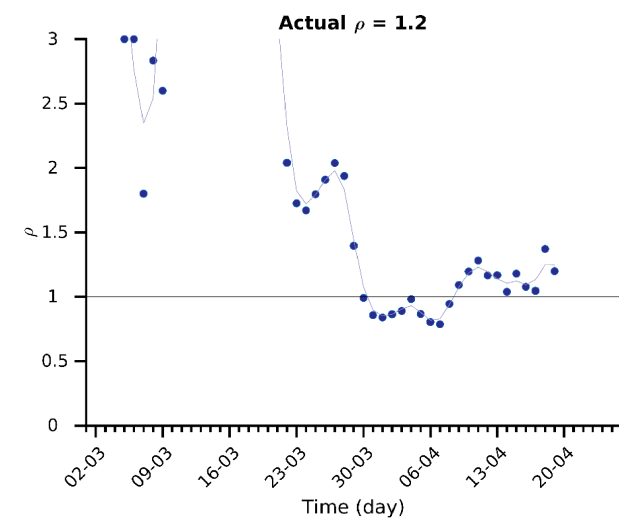
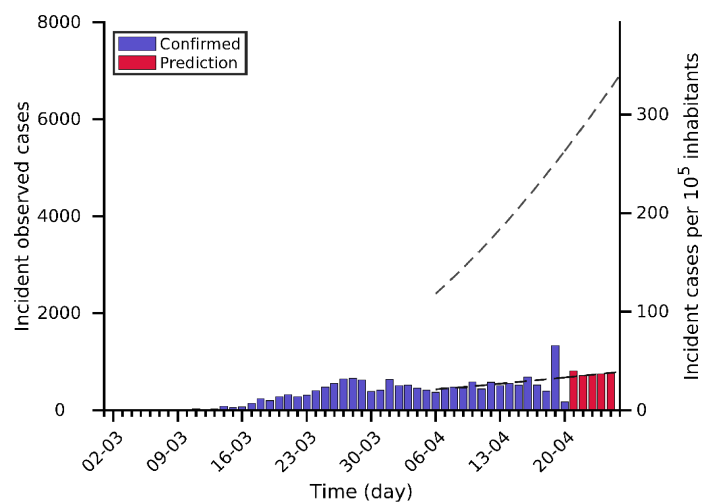
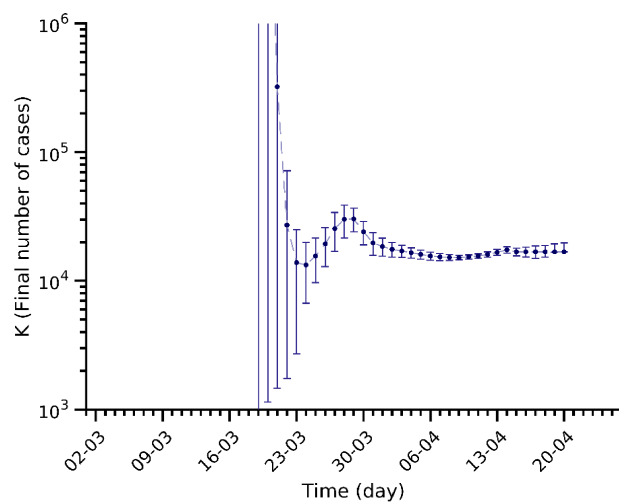
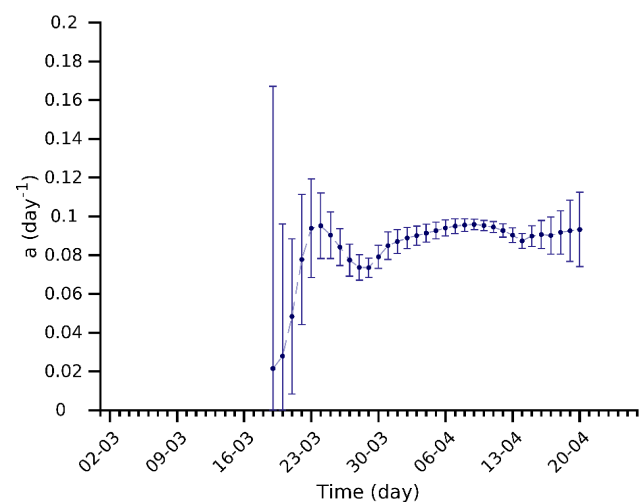
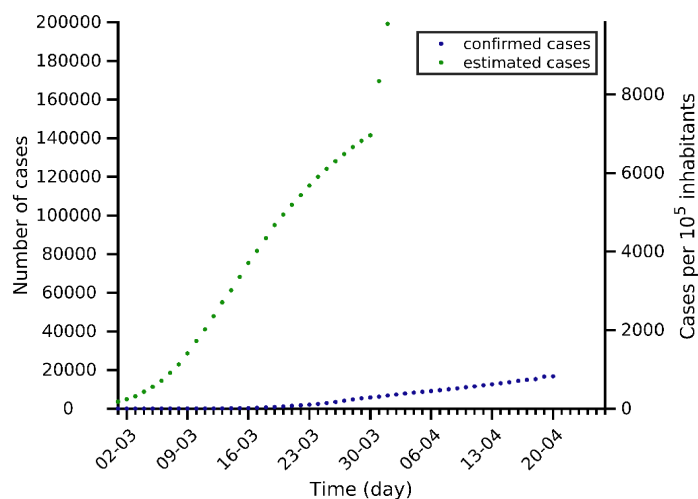
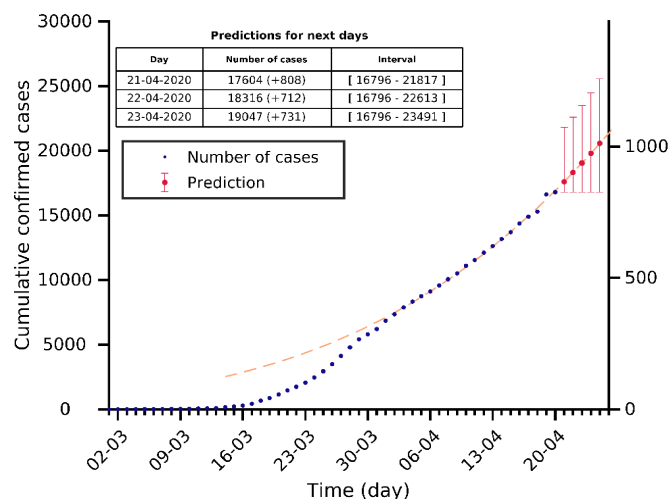
Madrid 20-04-2020. Population: 6.7M. Current cumulated incidence: 855/10⁵



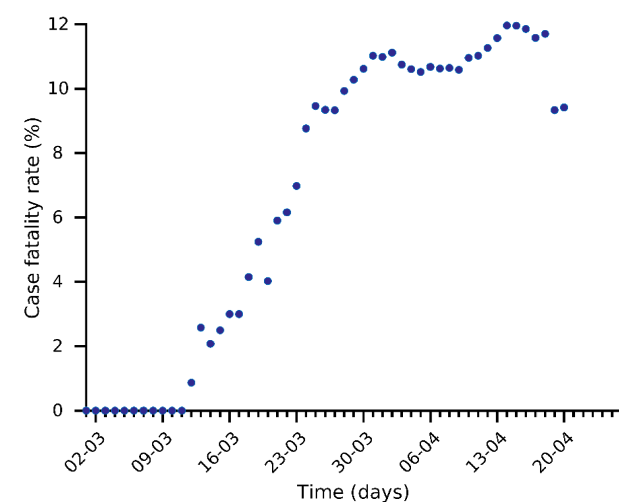
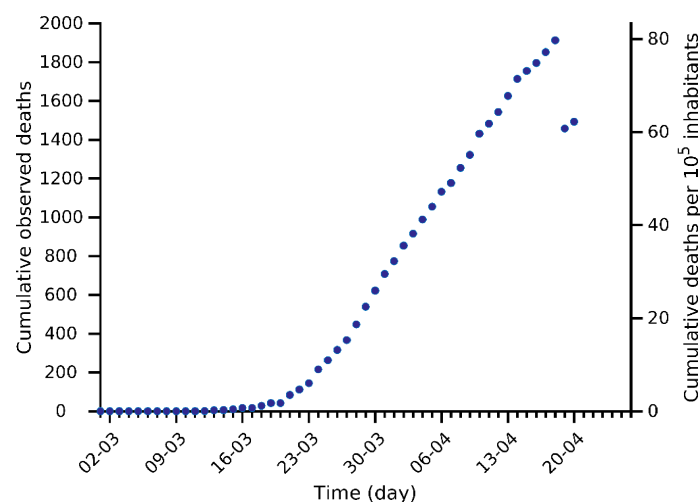
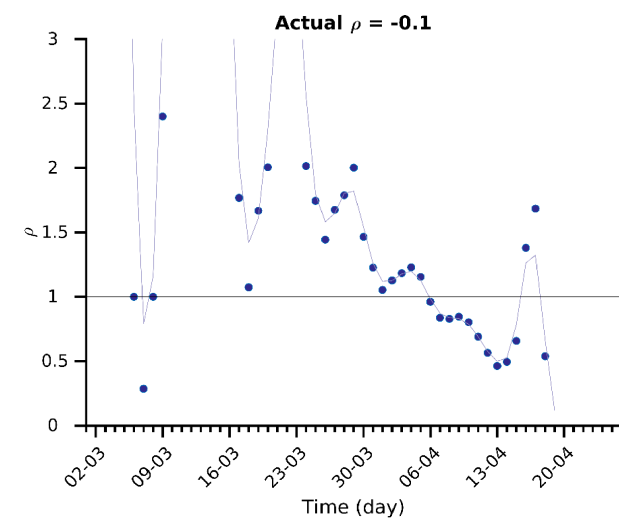
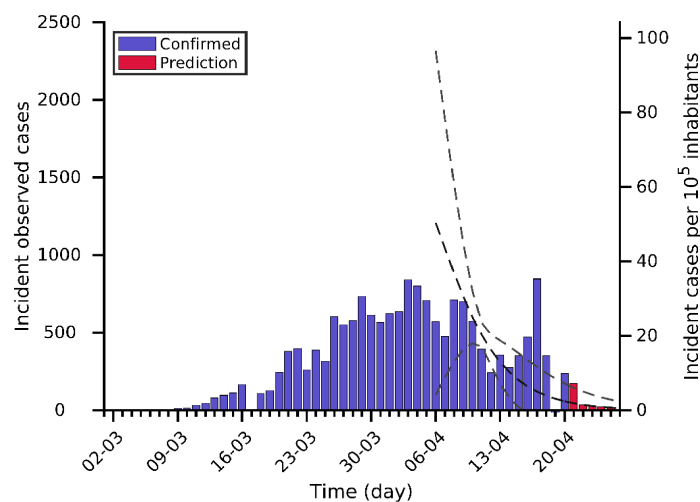
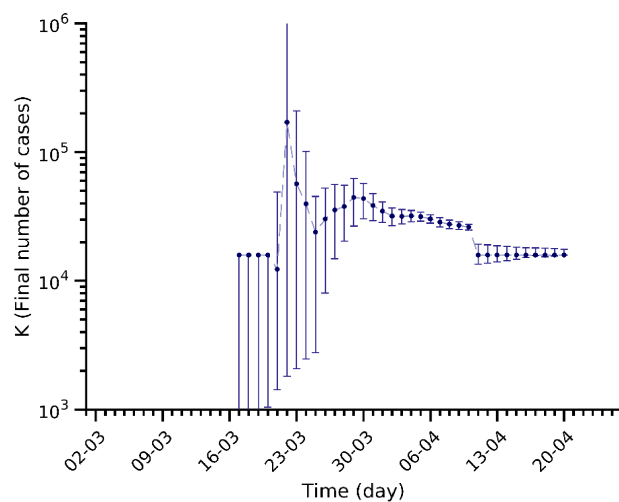
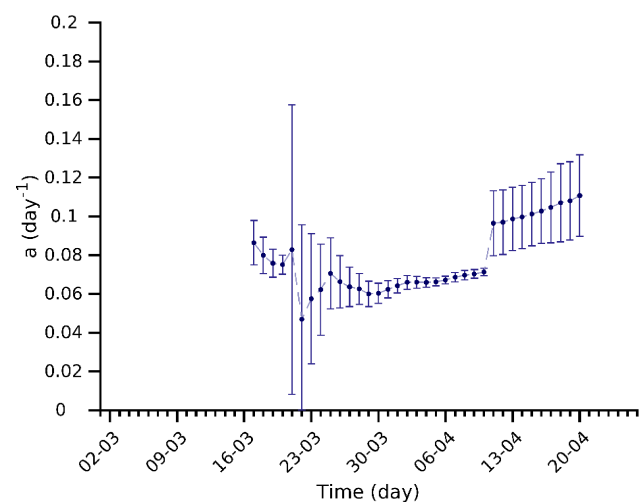
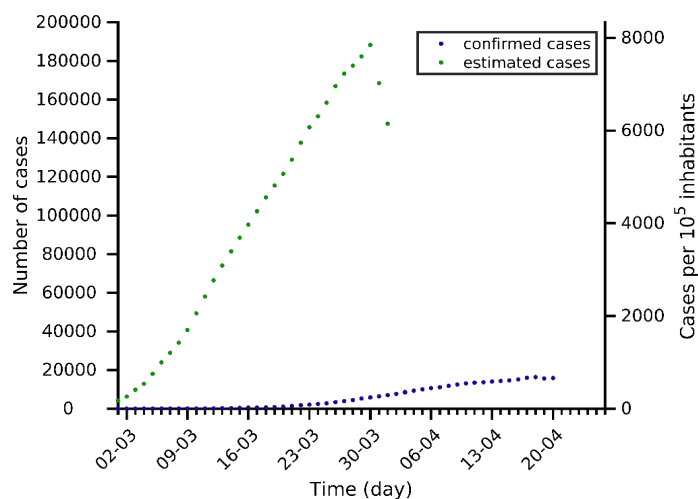
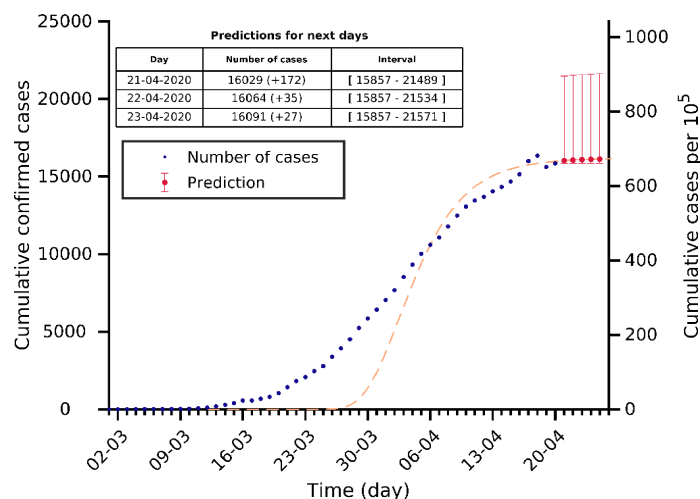
Catalunya 20-04-2020. Population: 7.7M. Current cumulated incidence: 543/10⁵



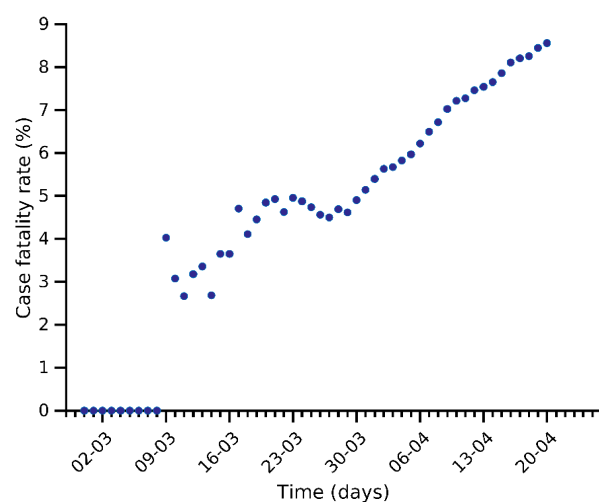
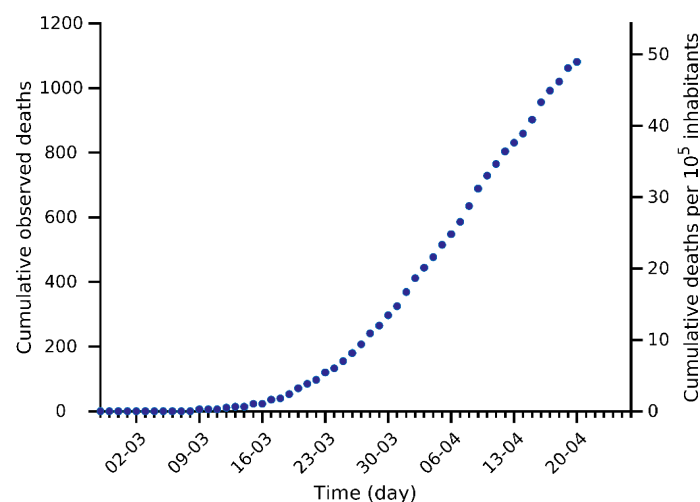
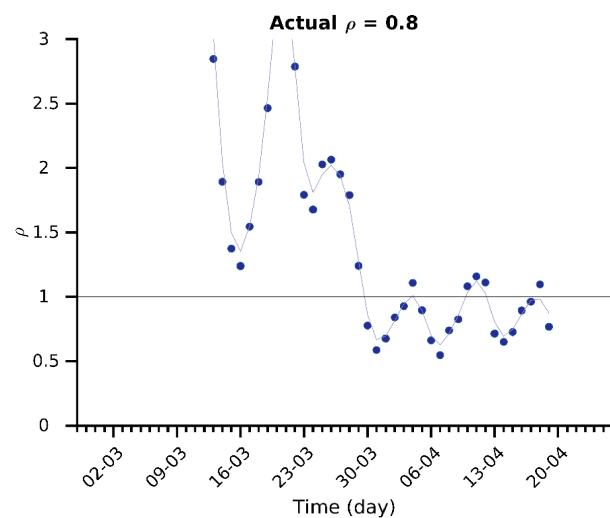
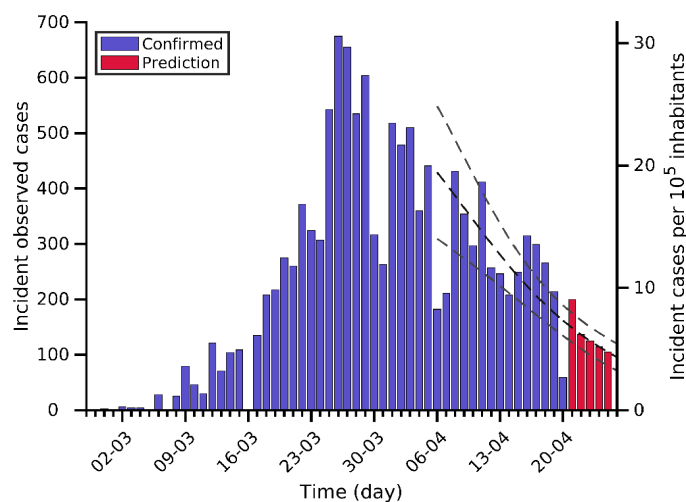
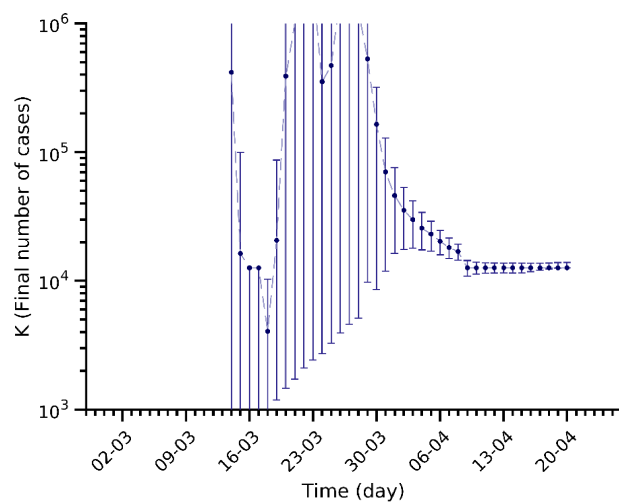
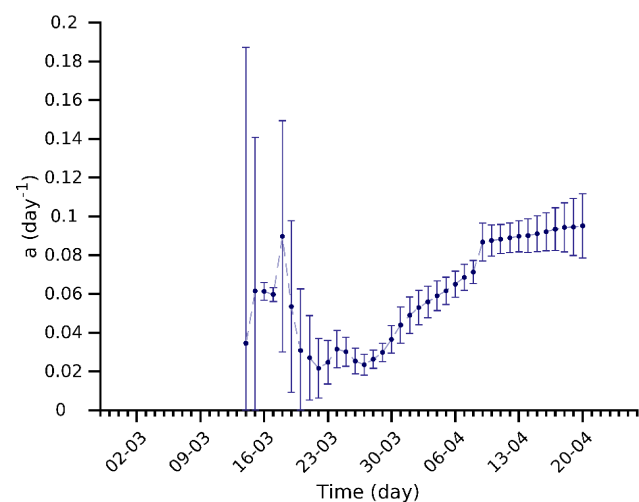
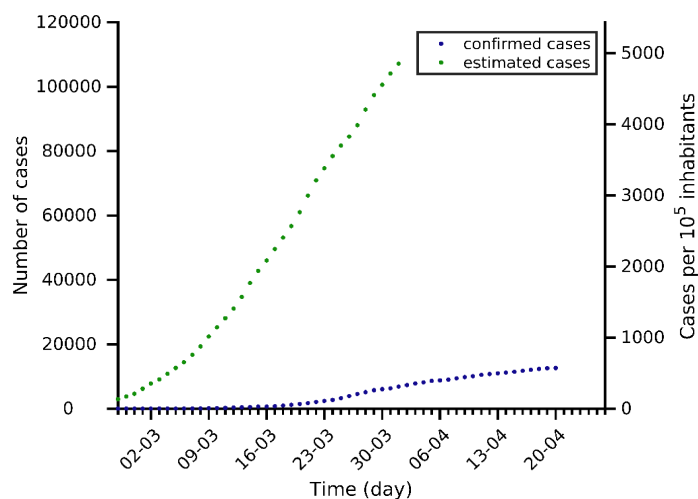
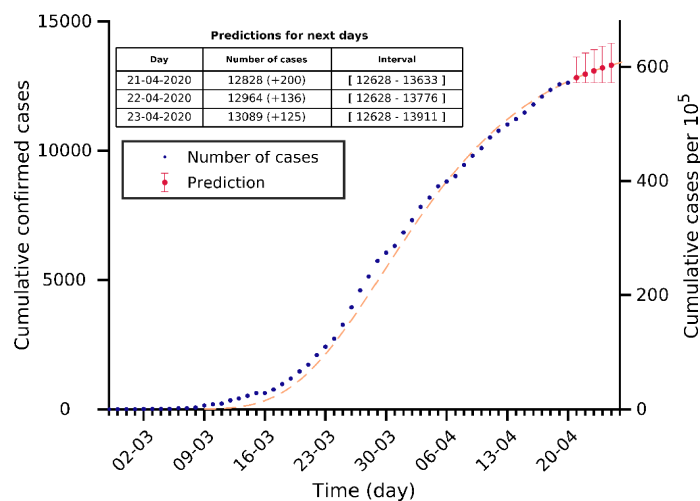
Castilla-La Mancha 20-04-2020. Population: 2.0M. Current cumulated incidence: 82



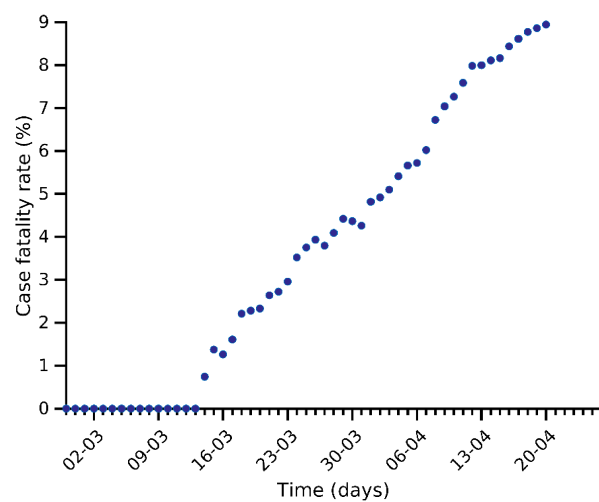
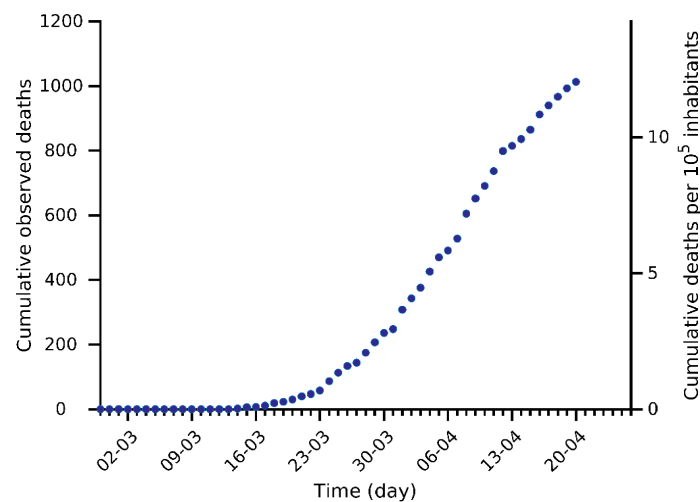
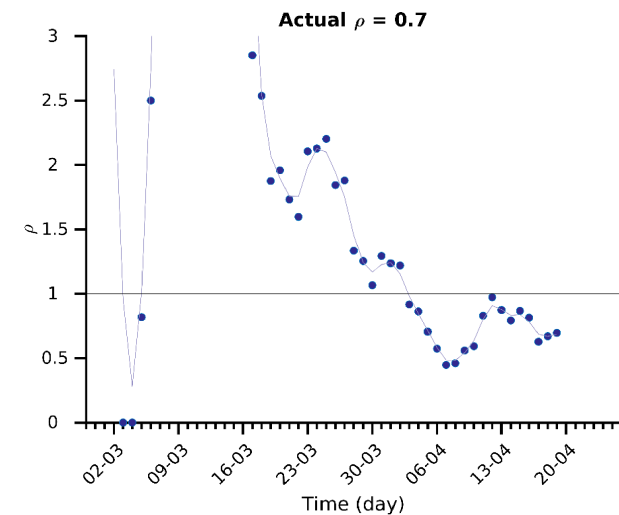
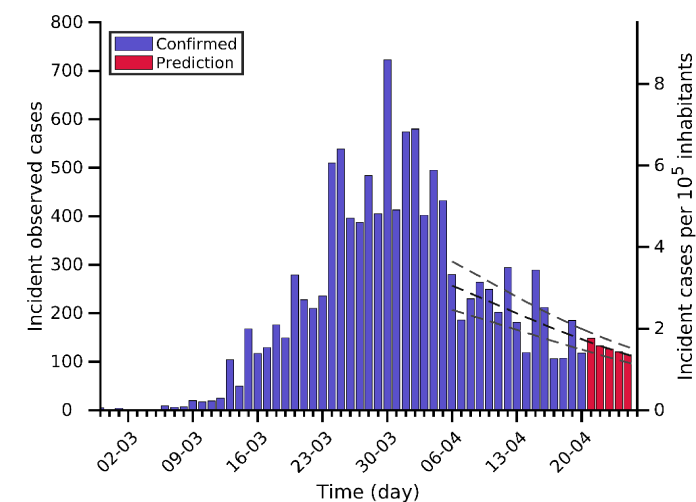
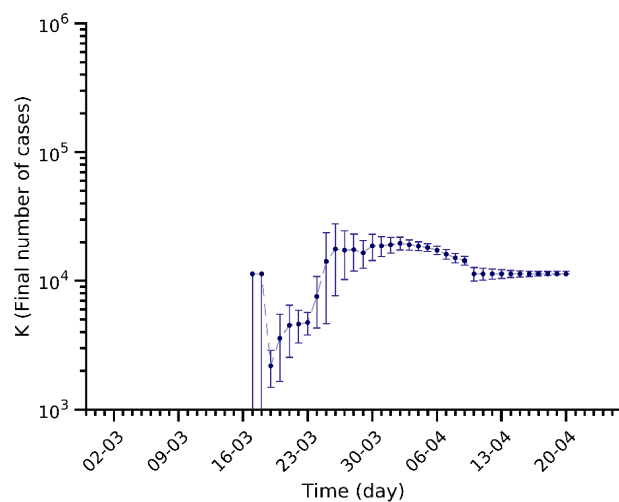
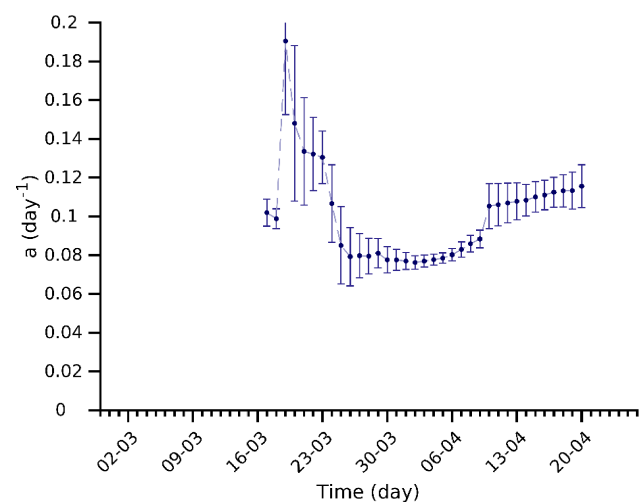
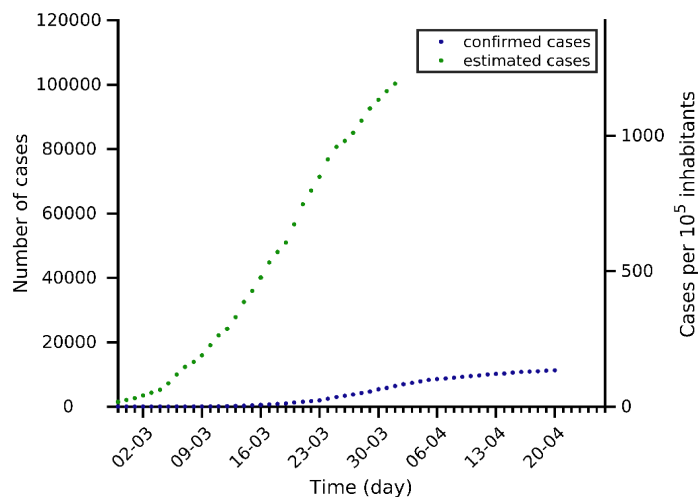
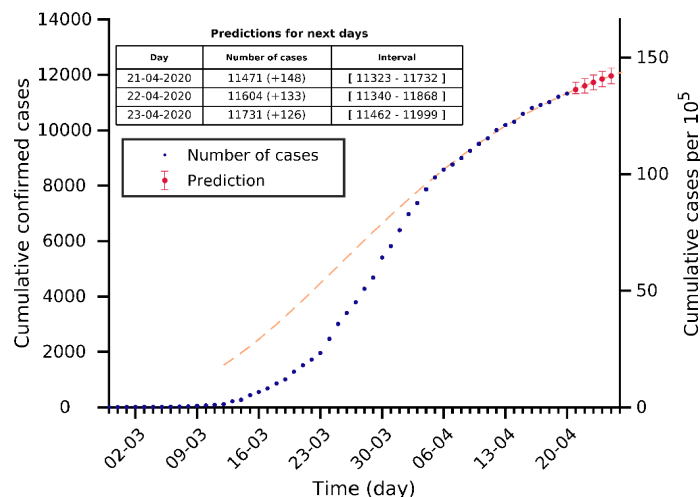
Castilla Leon 20-04-2020. Population: 2.4M. Current cumulated incidence: 661/10⁵



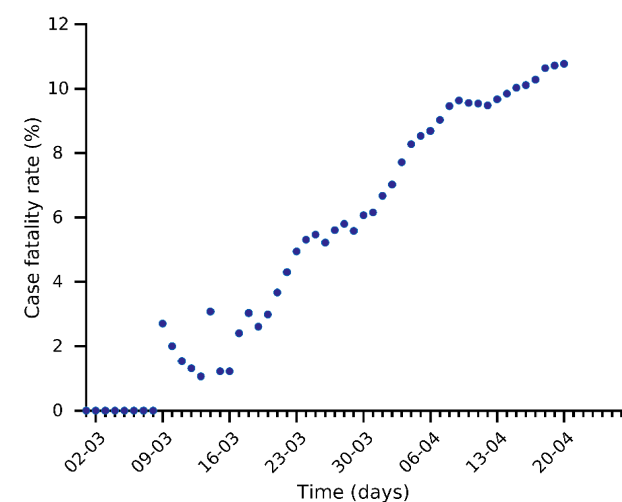
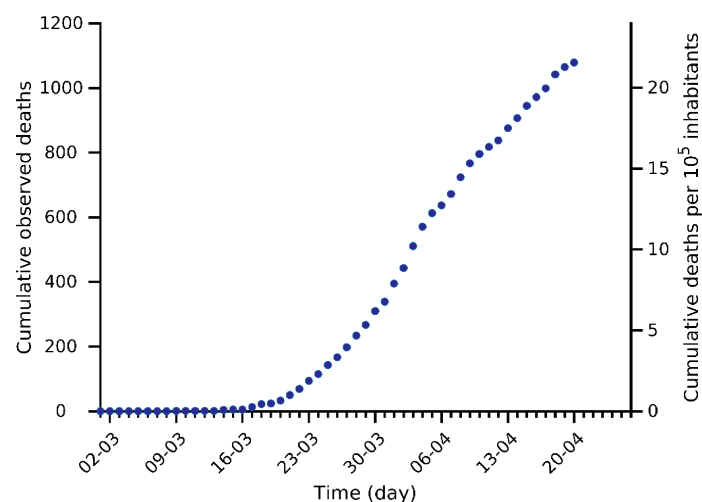
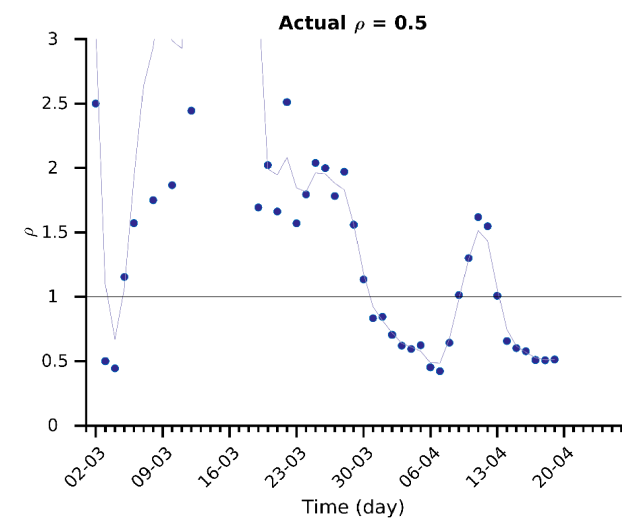
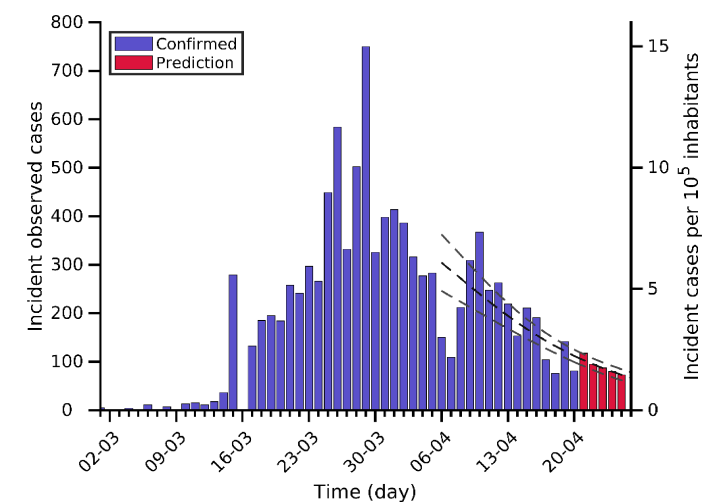
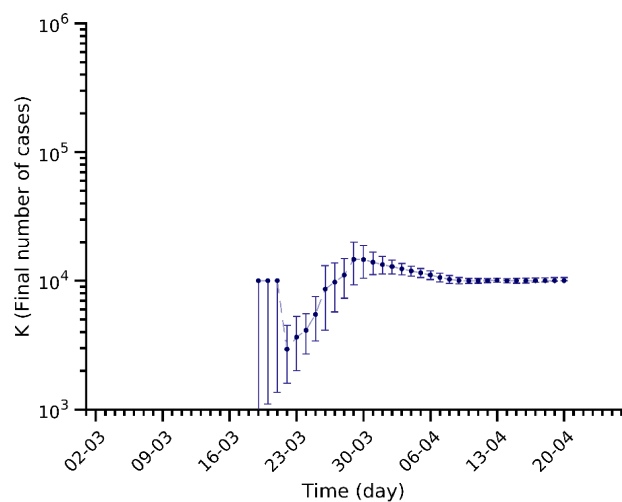
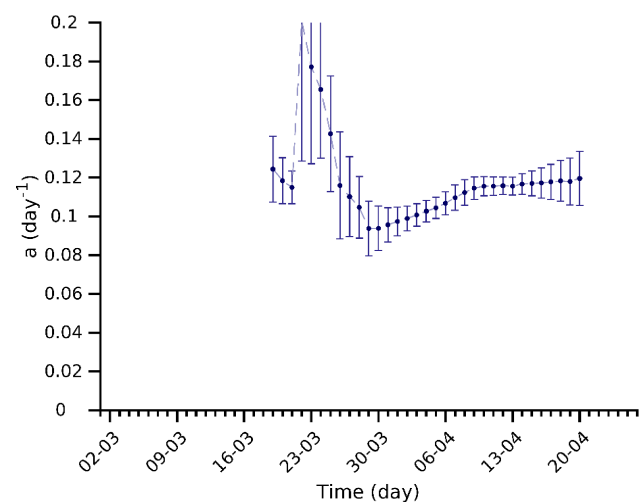
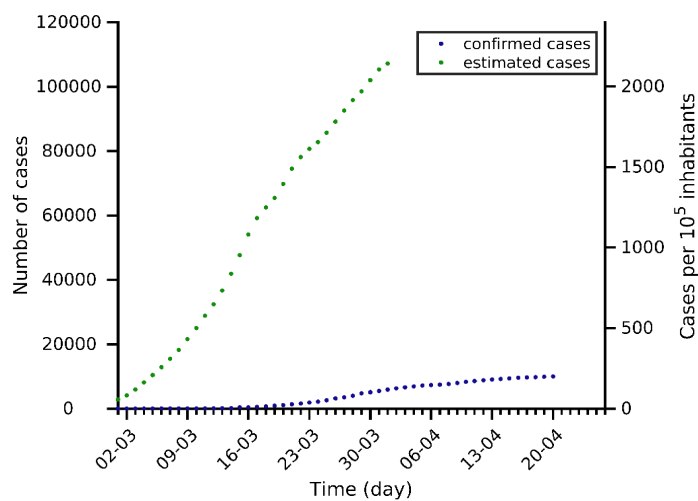
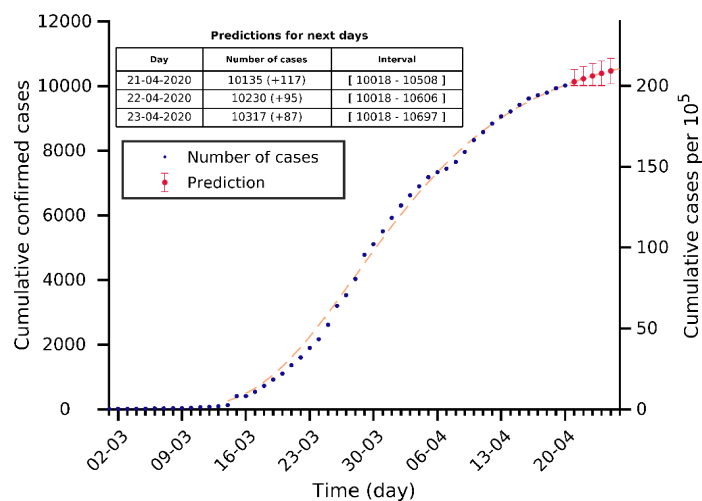
Euskadi 20-04-2020. Population: 2.2M. Current cumulated incidence: 572/10⁵



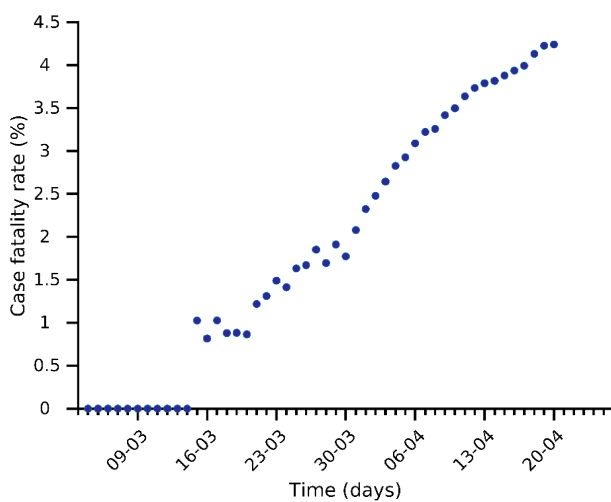
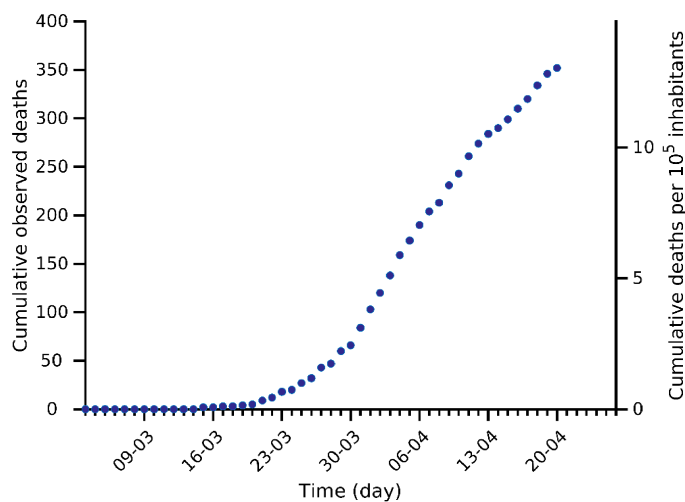
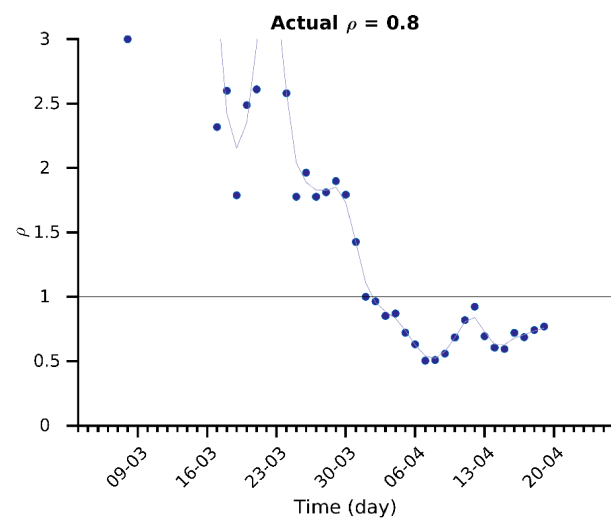
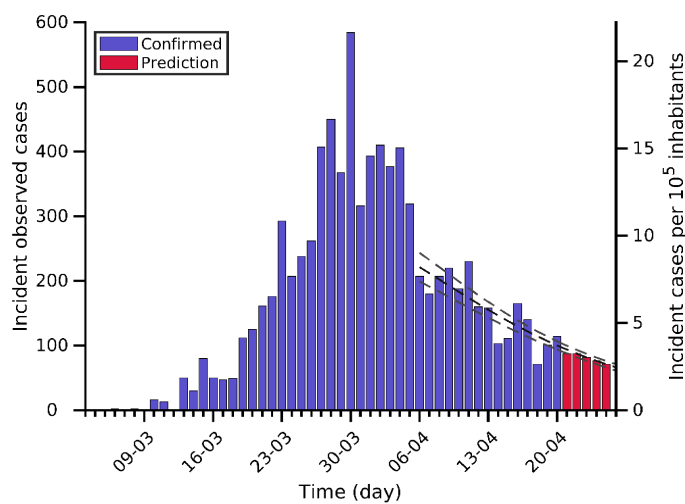
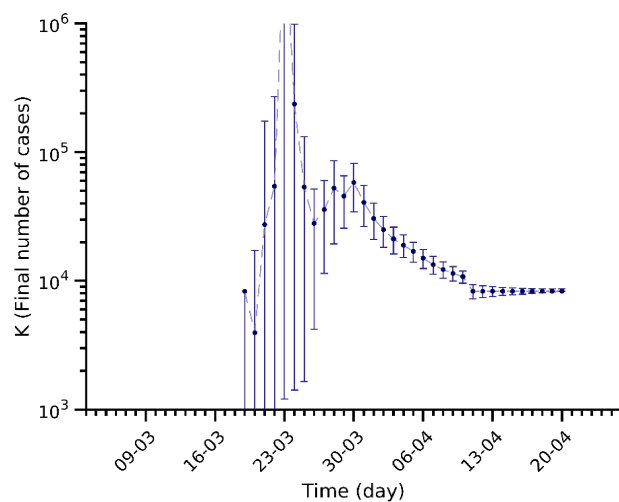
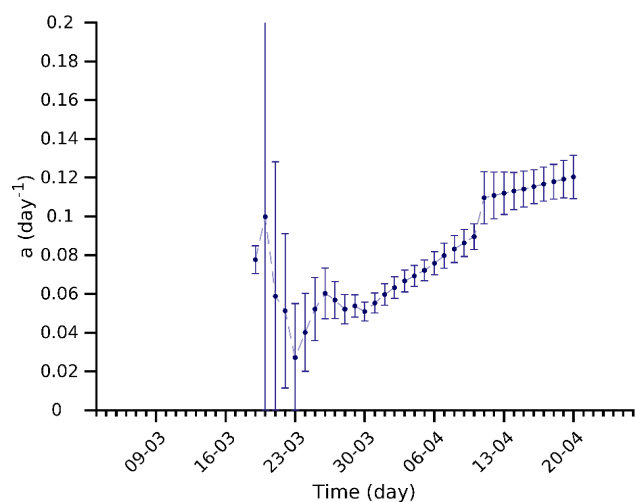
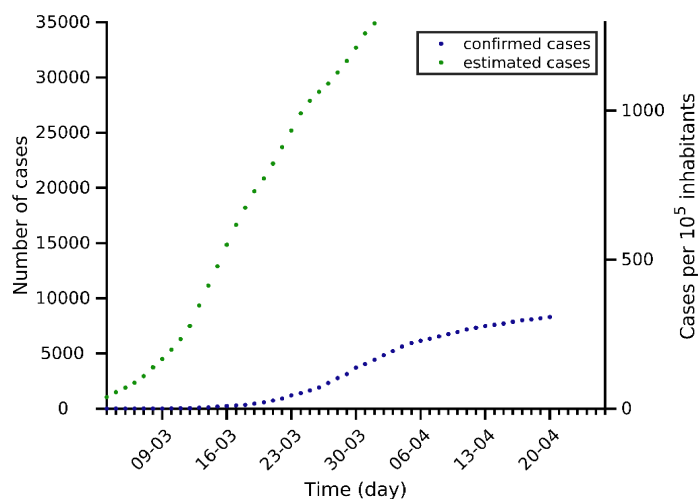
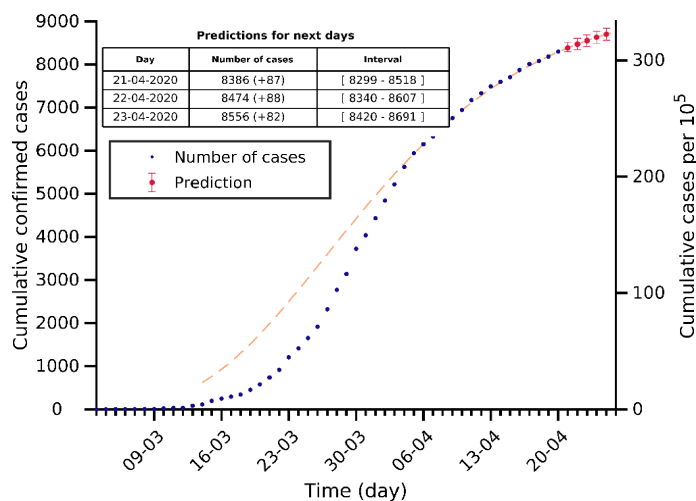
Andalucia 20-04-2020. Population: 8.4M. Current cumulated incidence: 135/10⁵



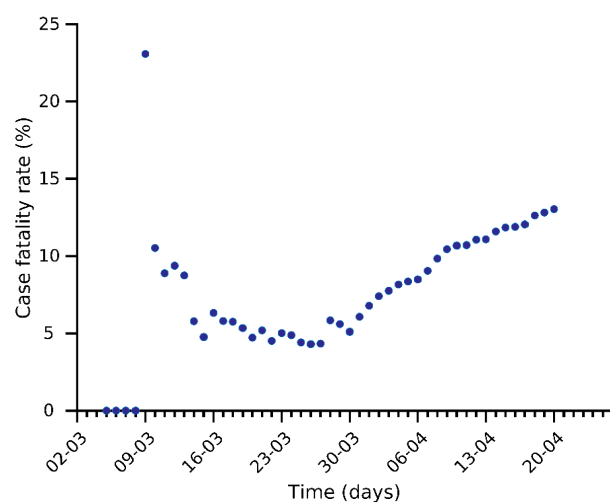
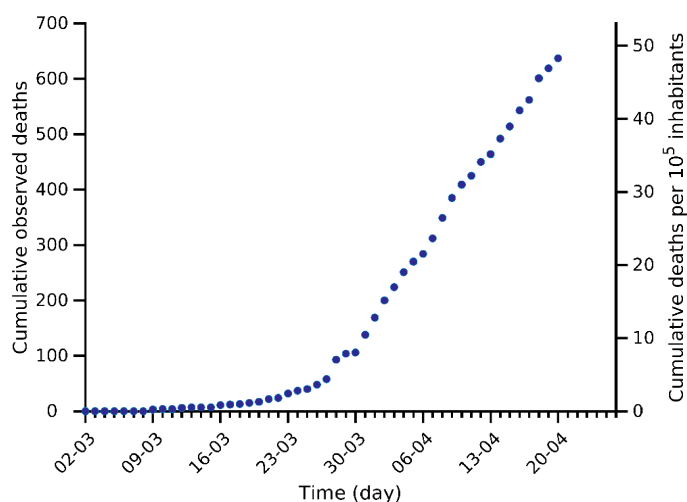
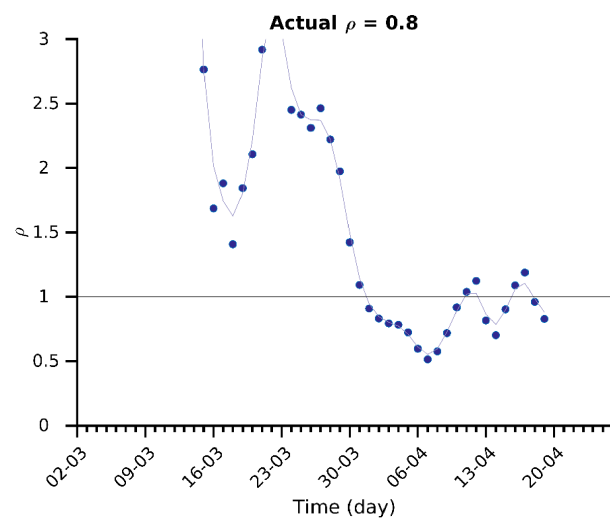
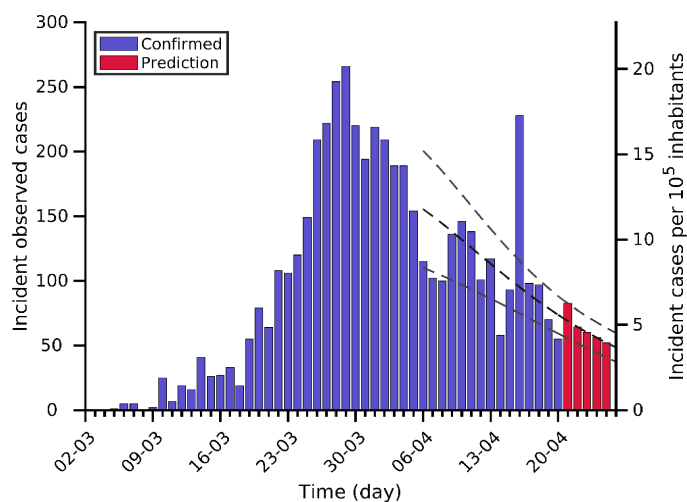
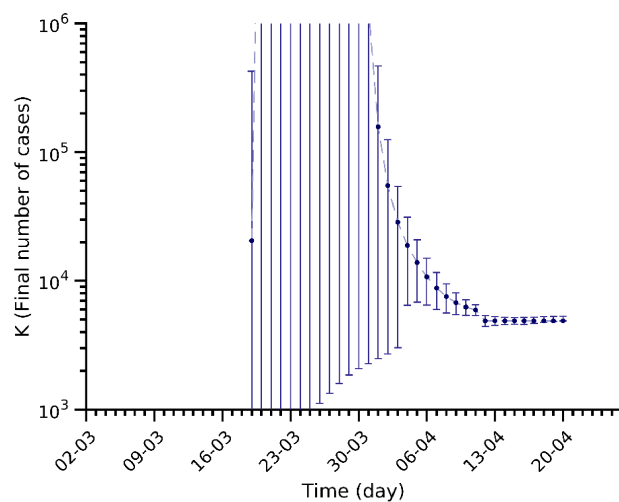
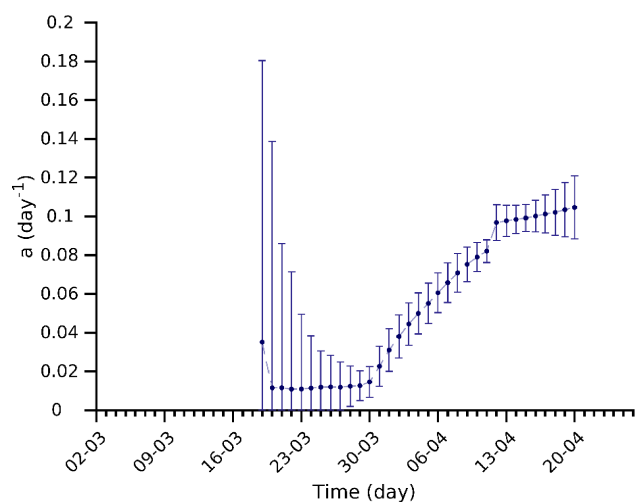
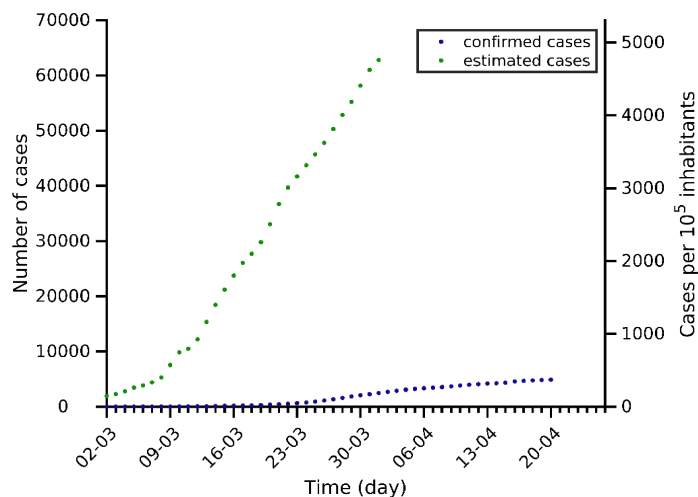
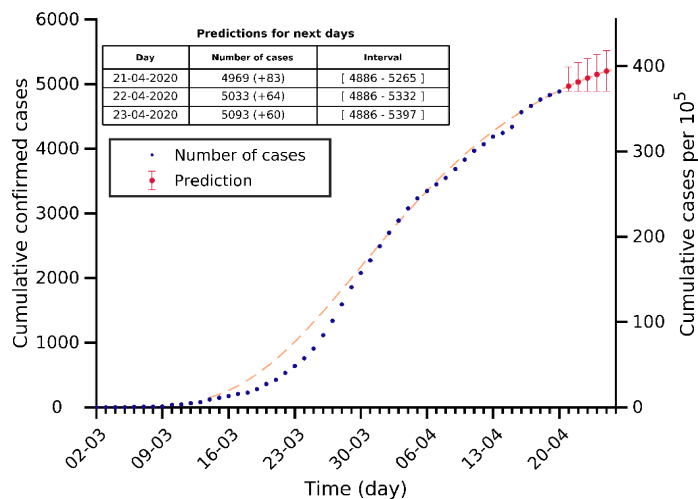
C Valenciana 20-04-2020. Population: 5.0M. Current cumulated incidence: 200/10⁵



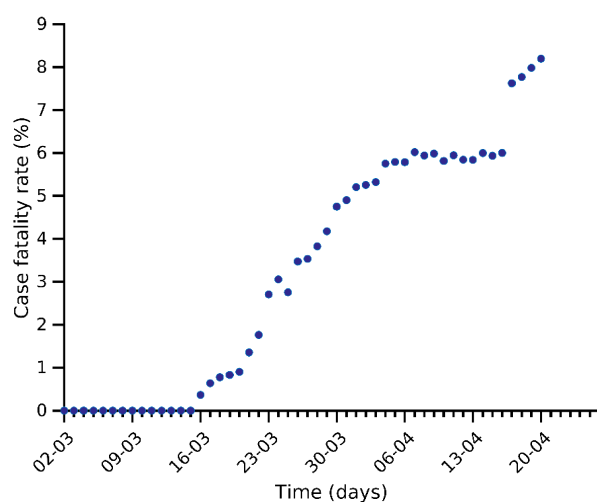
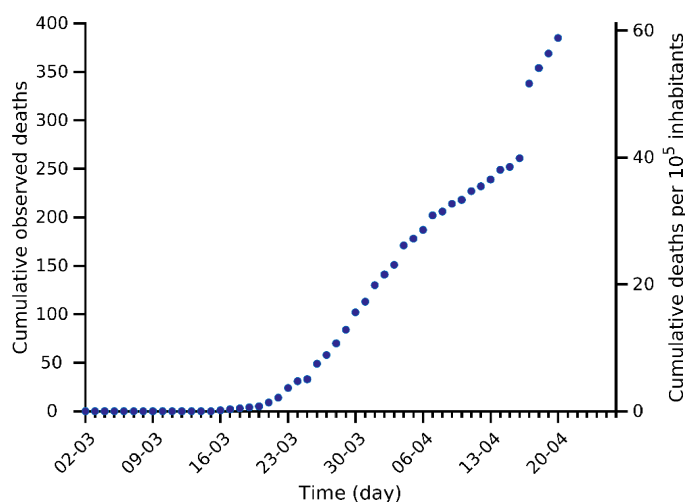
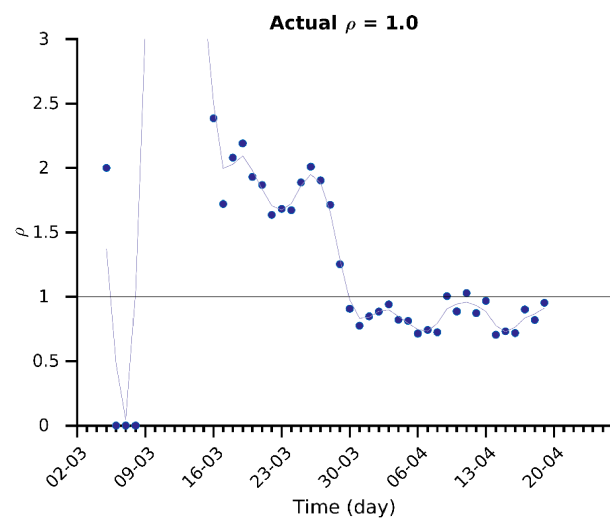
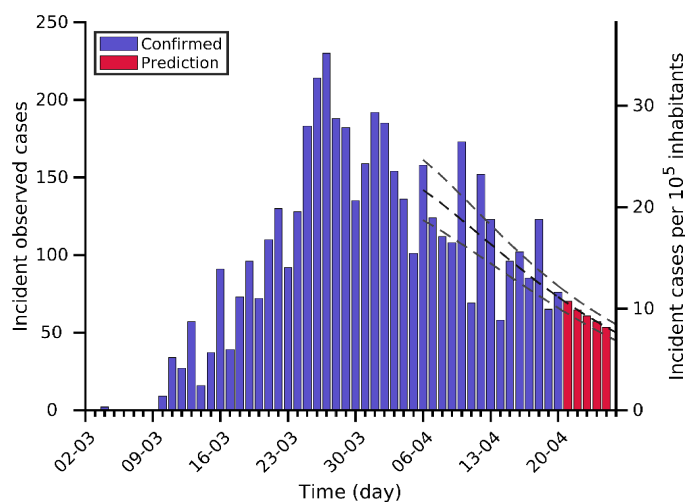
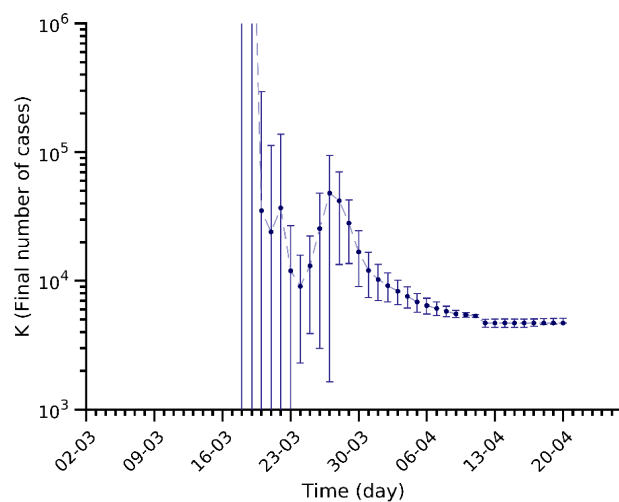
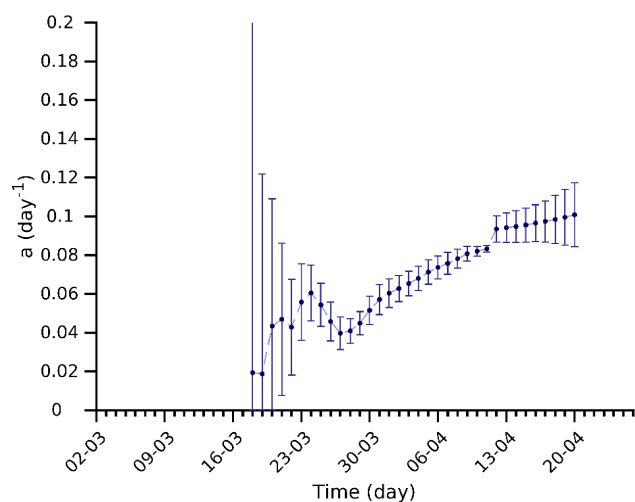
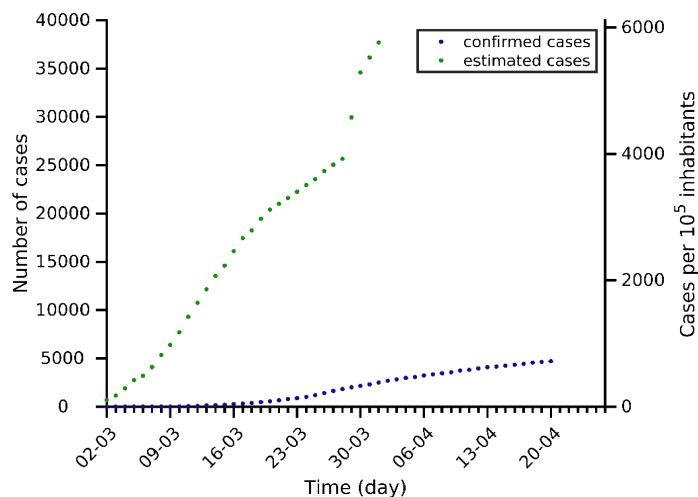
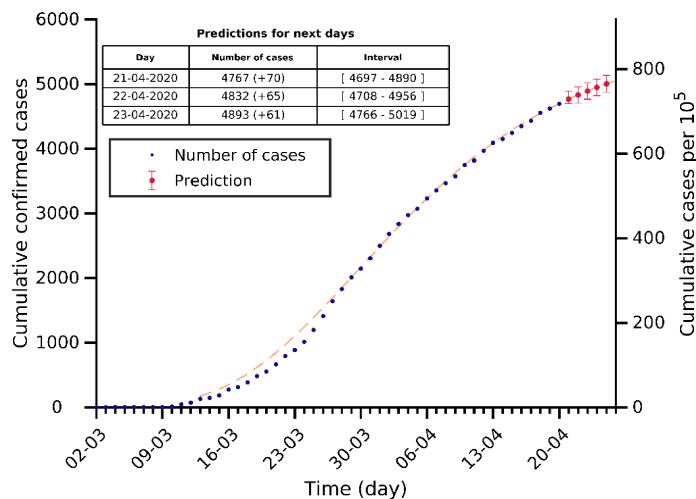
Galicia 20-04-2020. Population: 2.7M. Current cumulated incidence: 307/10⁵



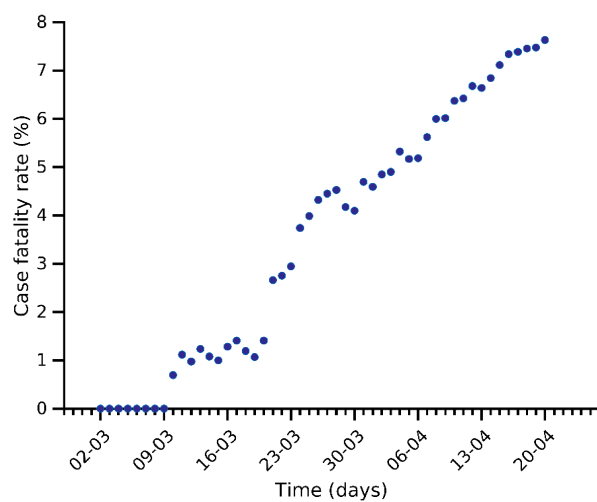
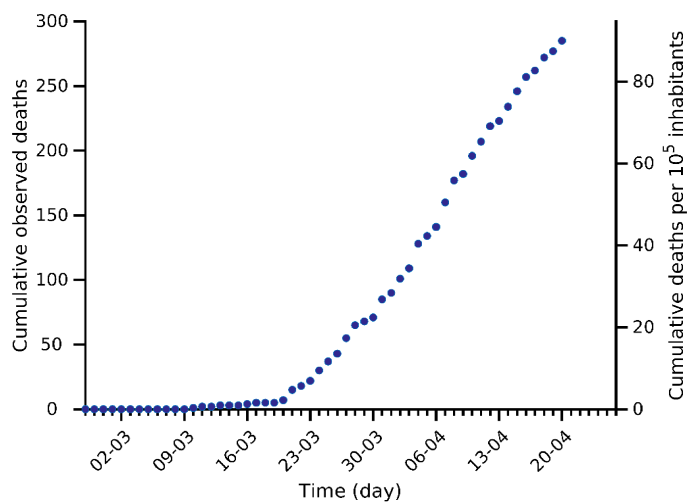
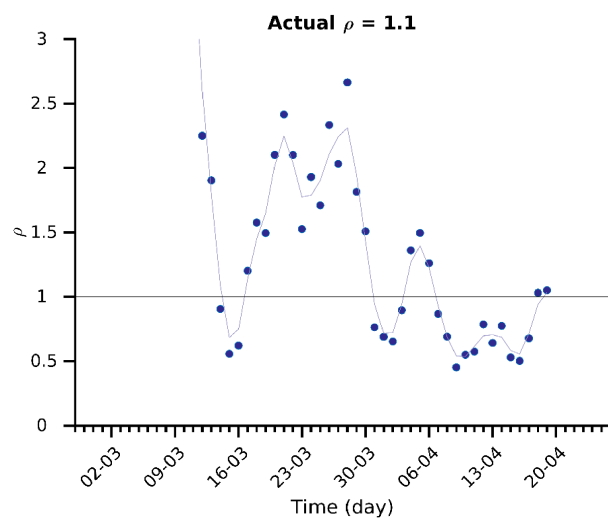
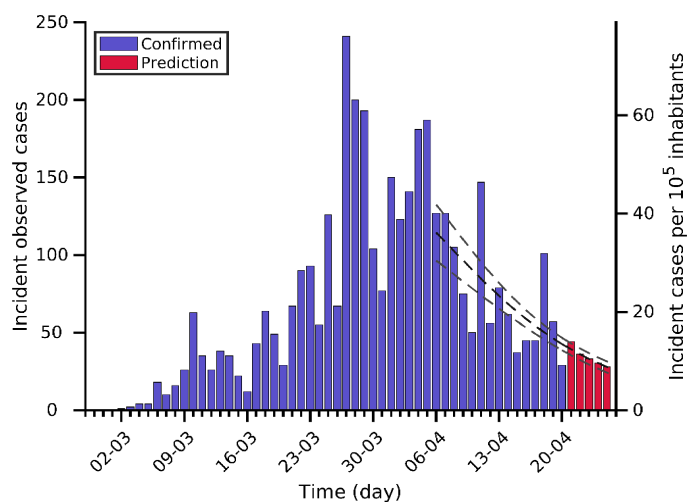
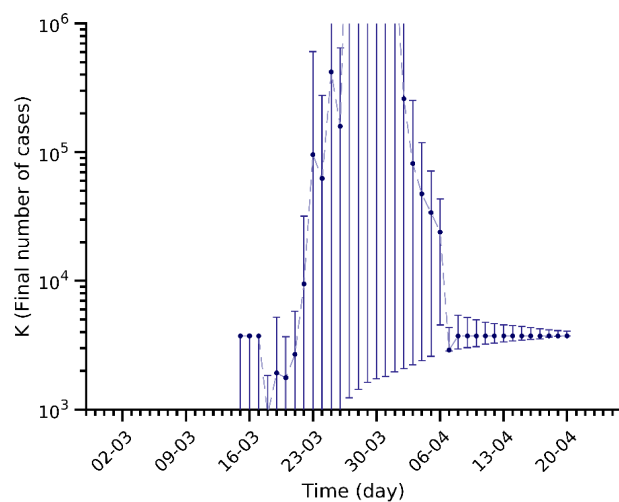
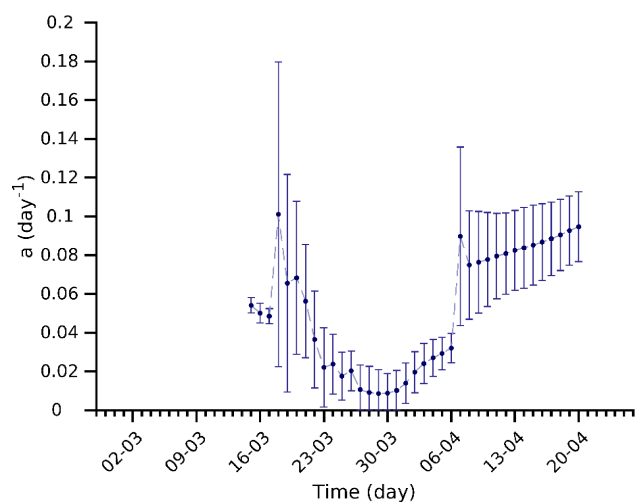
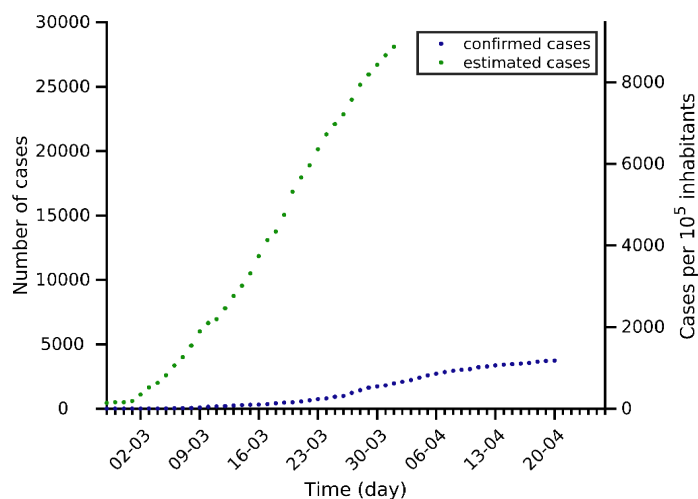
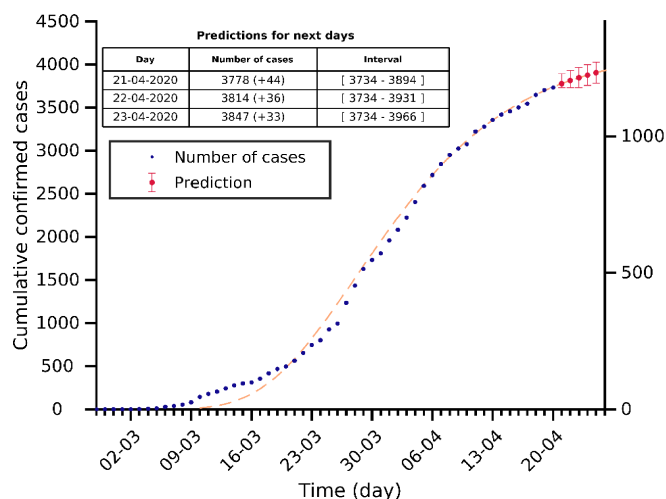
Aragon 20-04-2020. Population: 1.3M. Current cumulated incidence: 370/10⁵



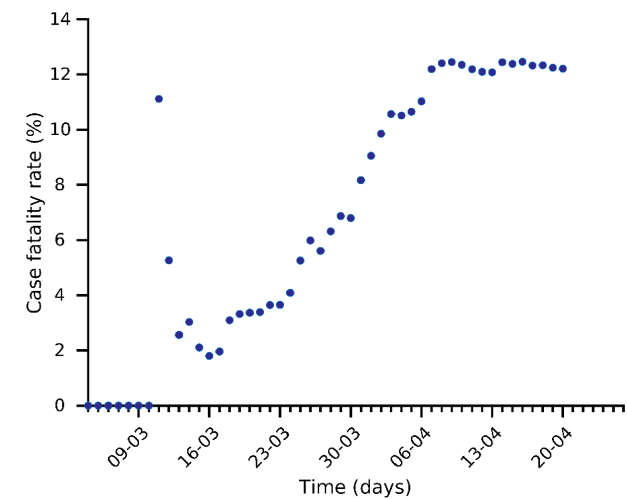
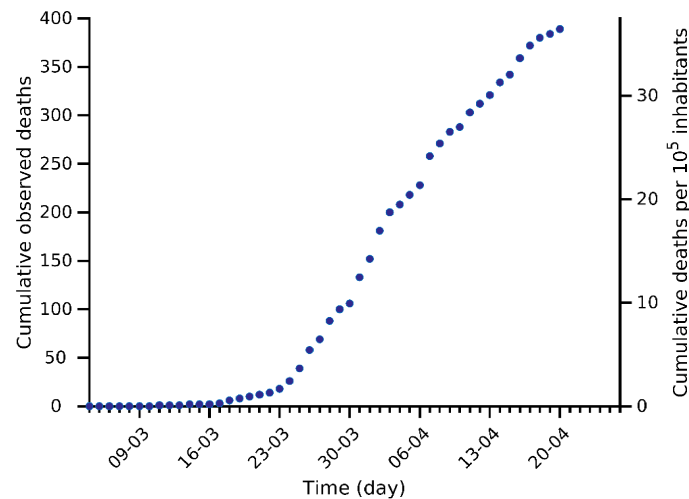
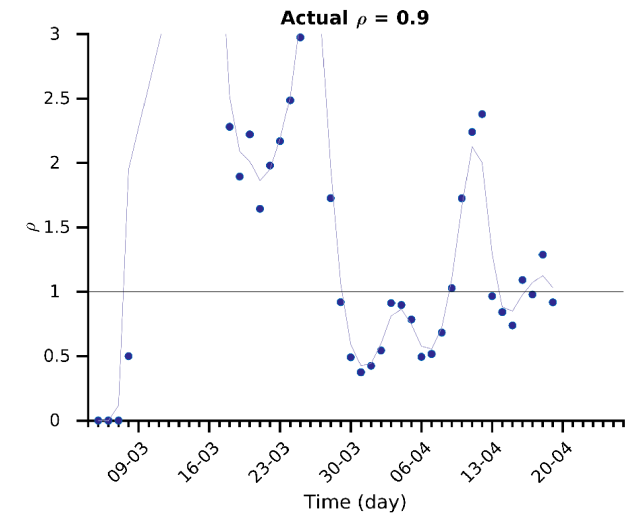
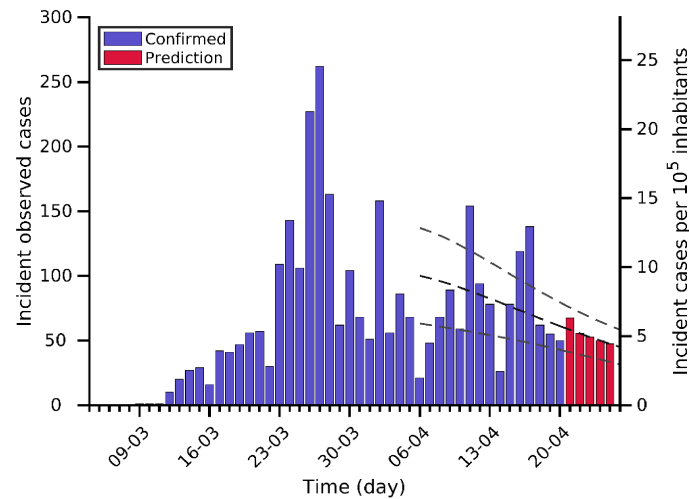
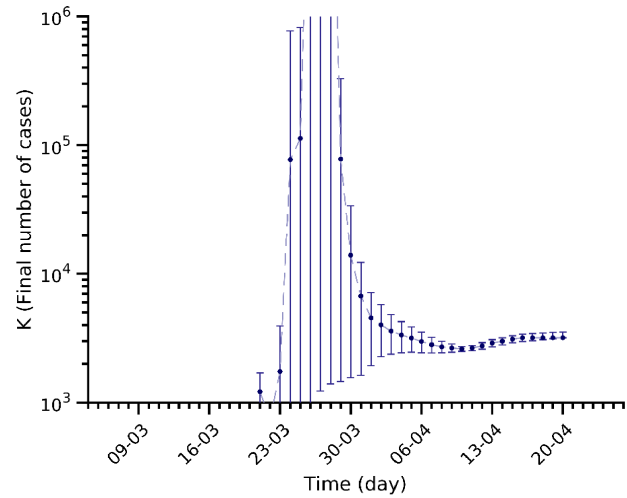
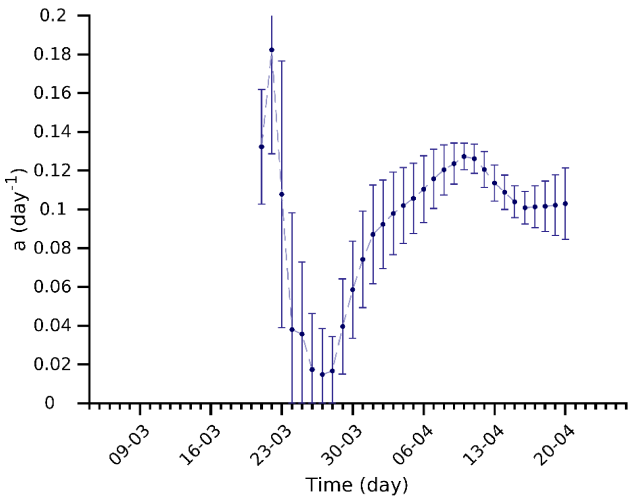
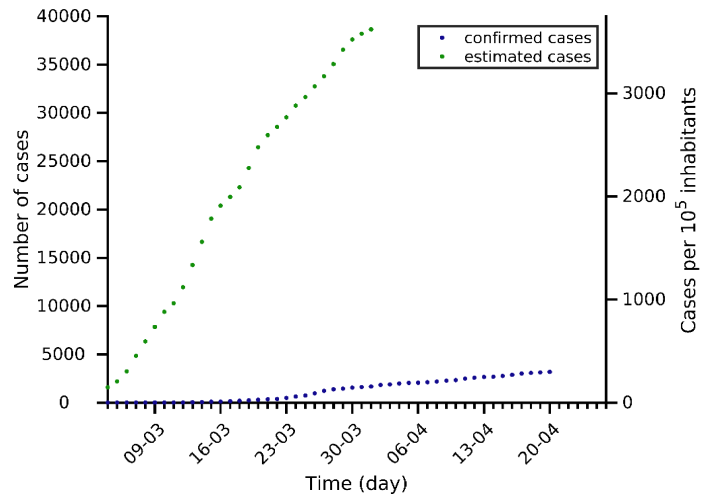
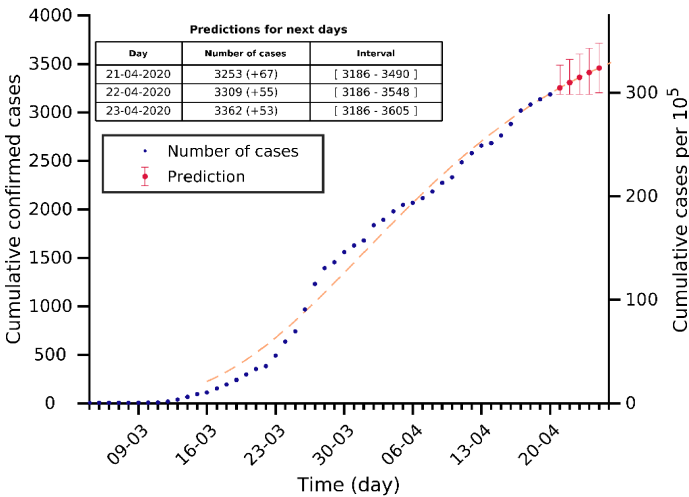
Navarra 20-04-2020. Population: 0.7M. Current cumulated incidence: 718/10⁵



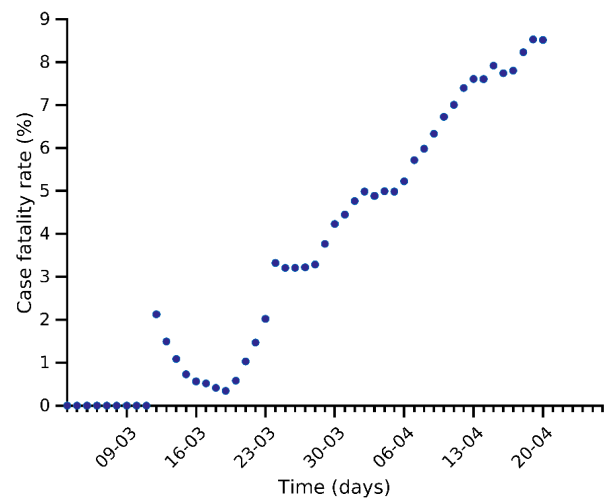
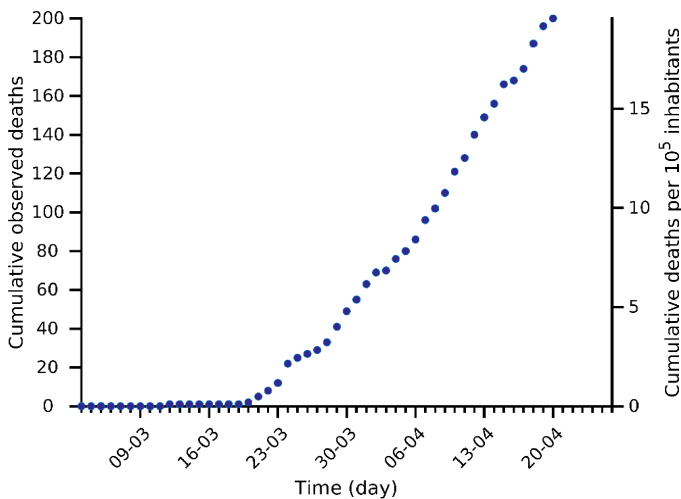
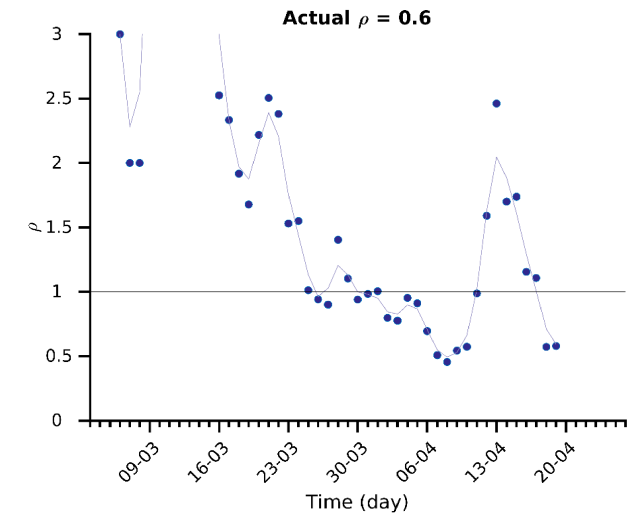
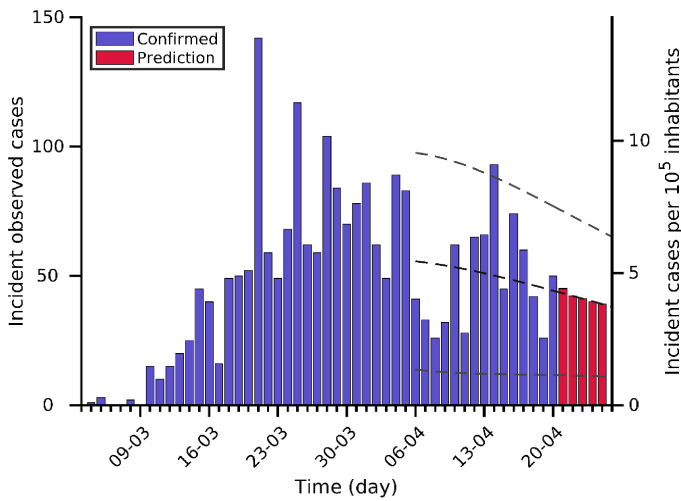
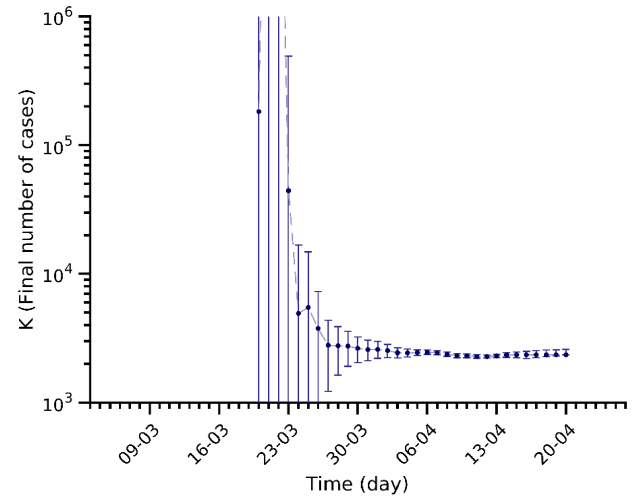
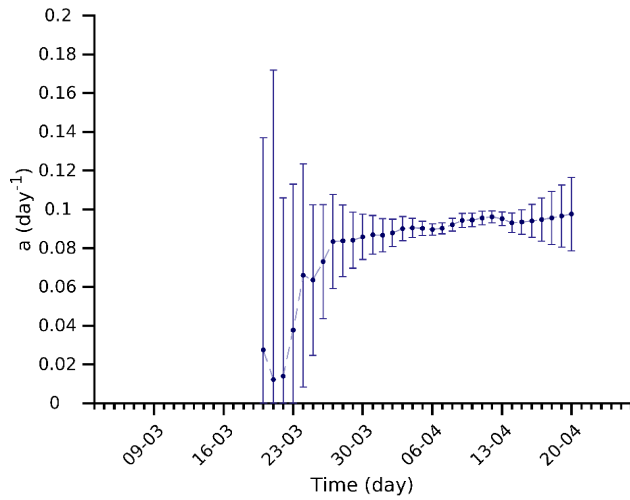
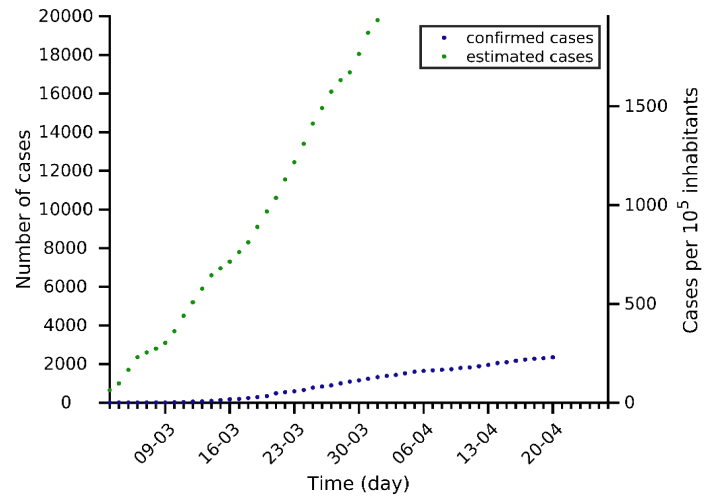
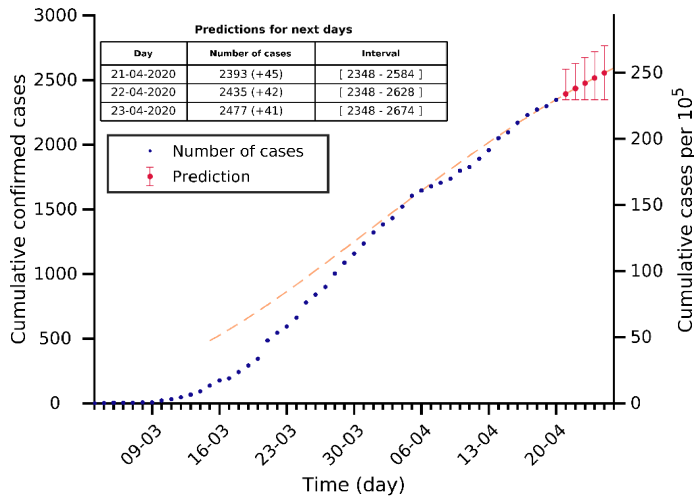
La Rioja 20-04-2020. Population: 0.3M. Current cumulated incidence: 1179/10⁵



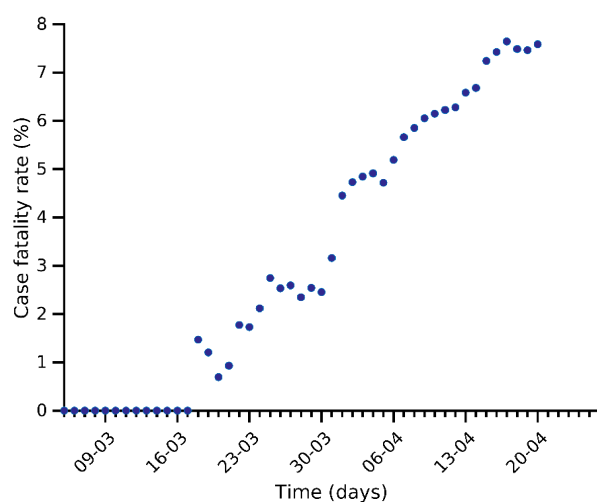
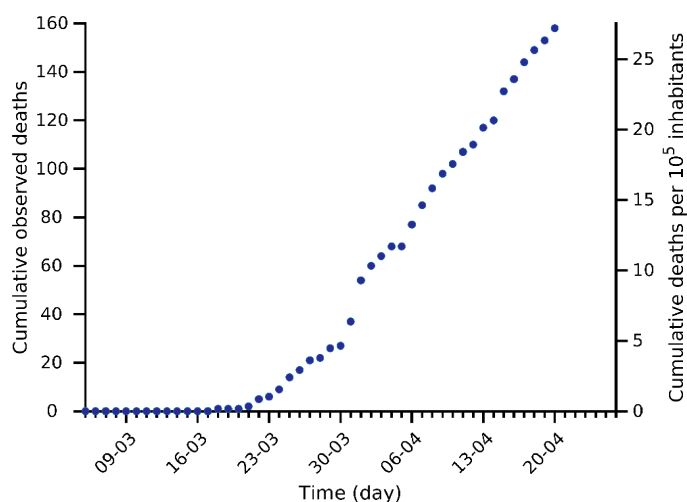
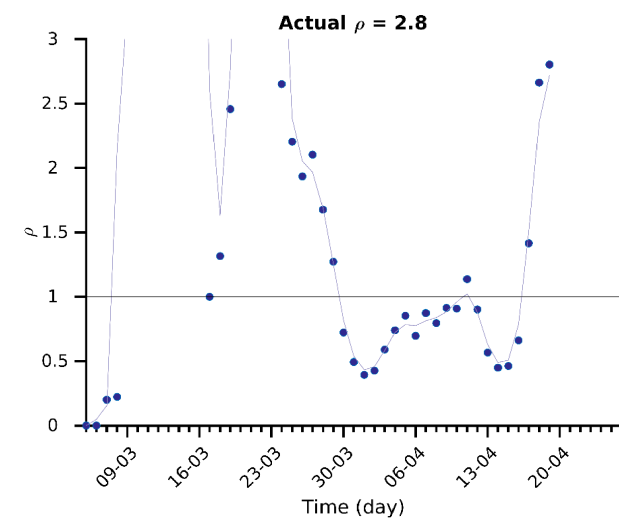
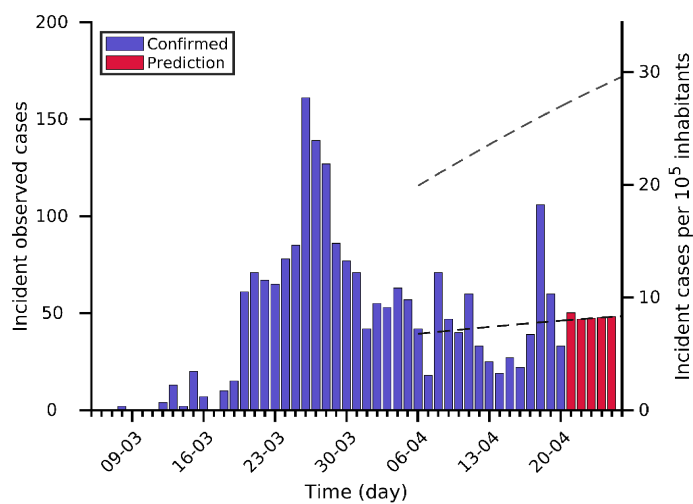
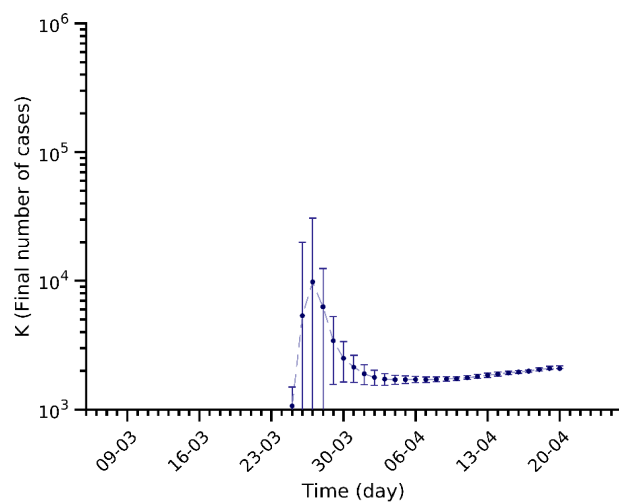
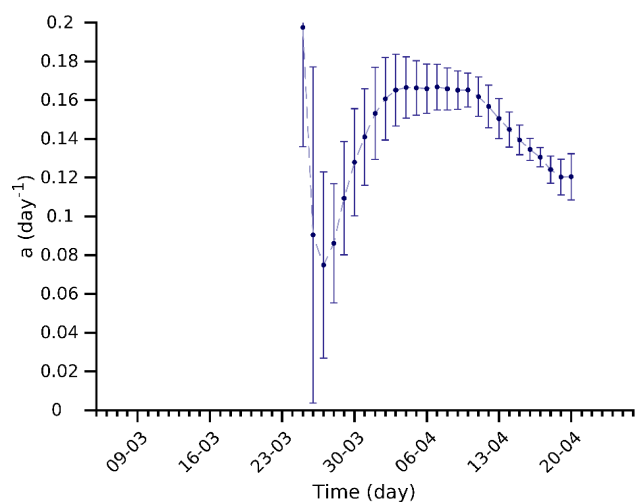
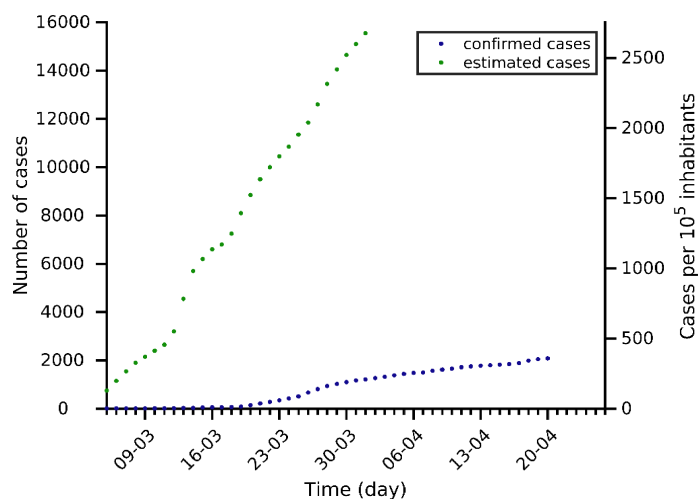
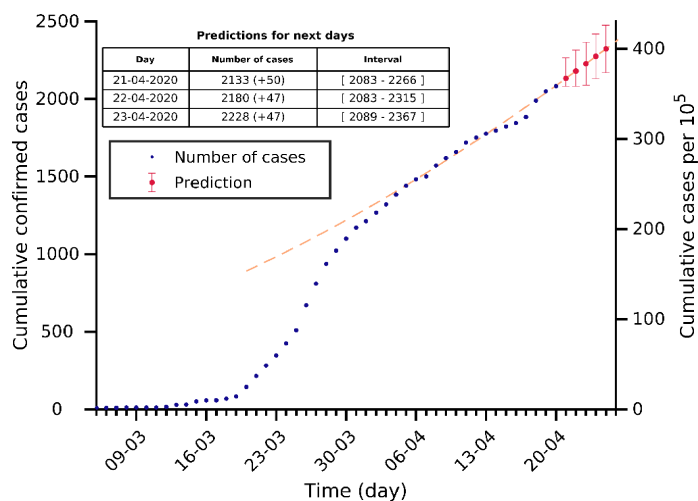
Extremadura 20-04-2020. Population: 1.1M. Current cumulated incidence: 298/10⁵



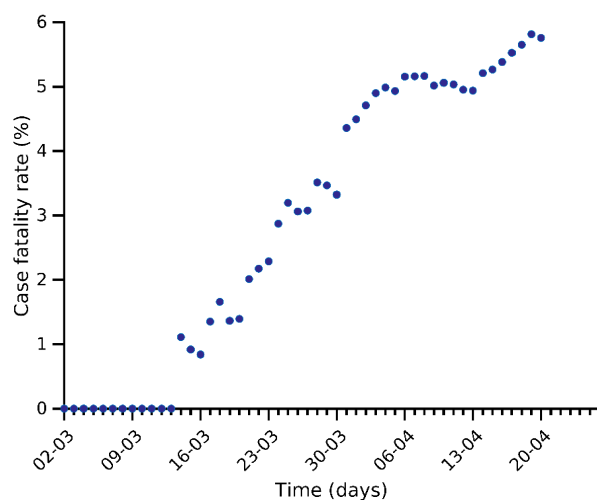
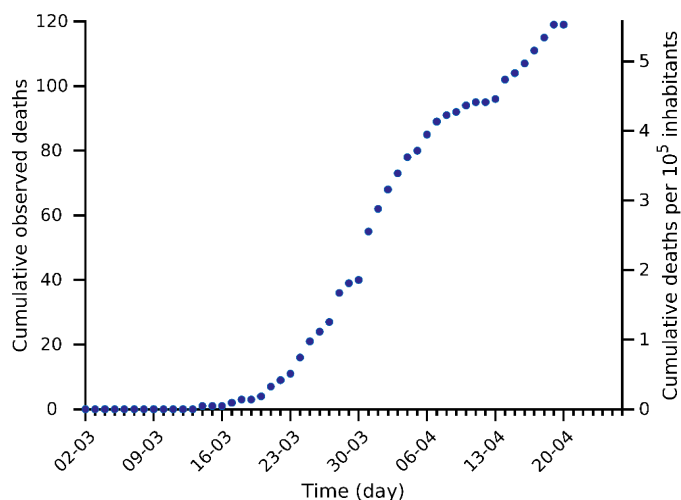
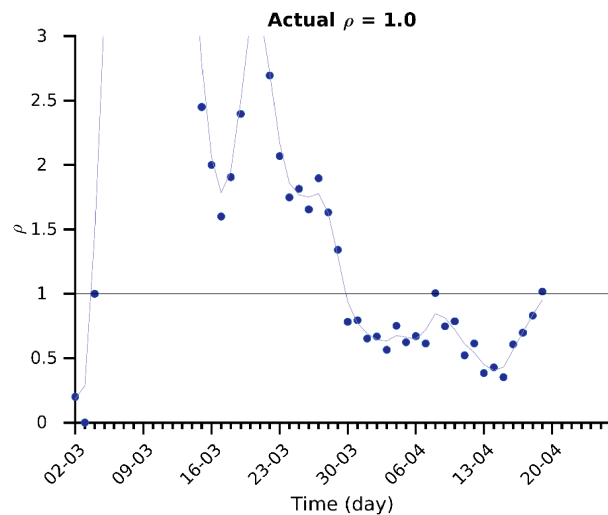
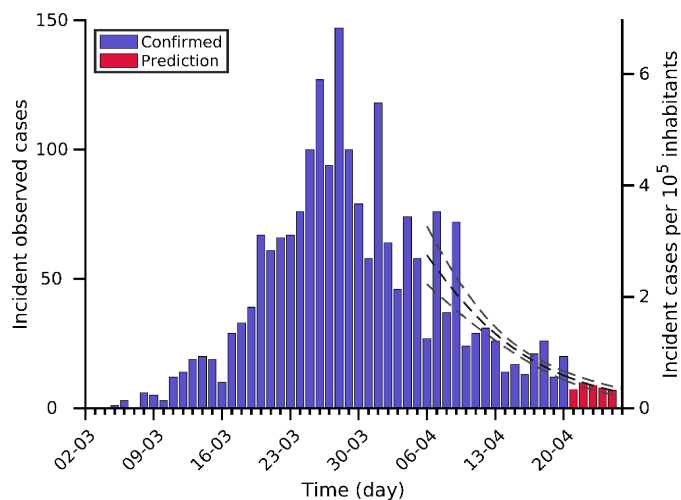
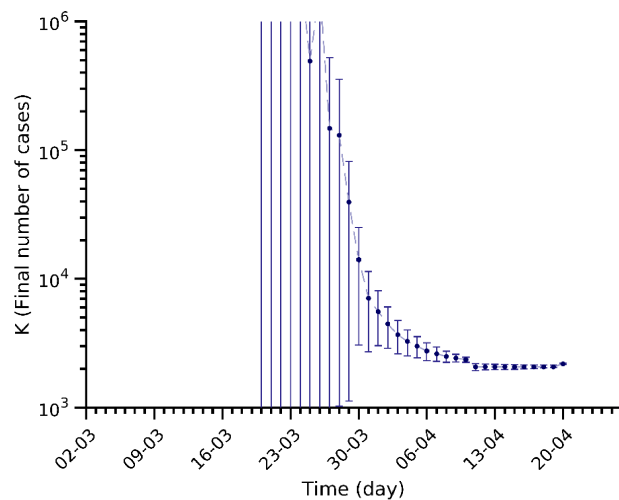
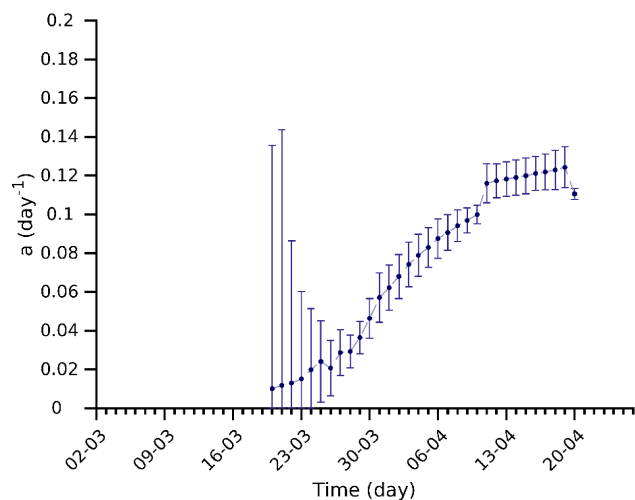
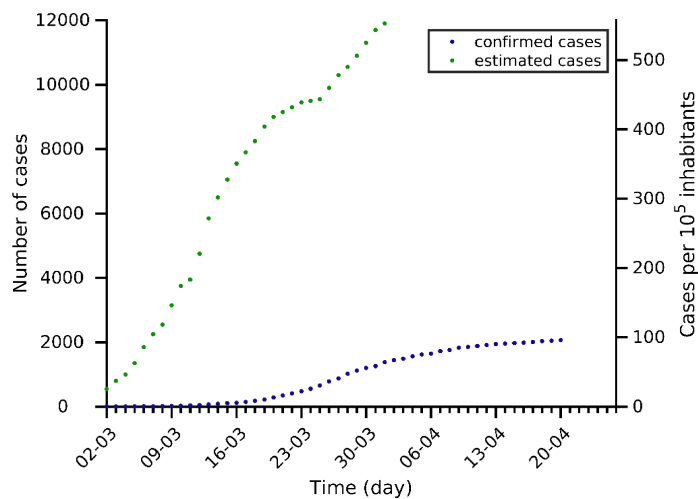
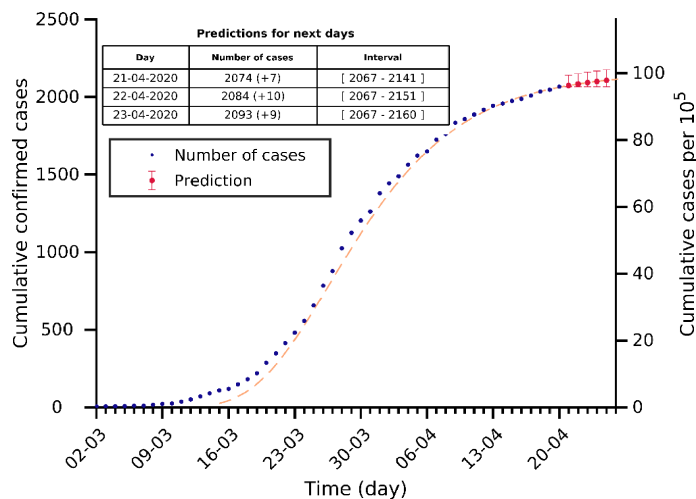
Asturias 20-04-2020. Population: 1.0M. Current cumulated incidence: 230/10⁵



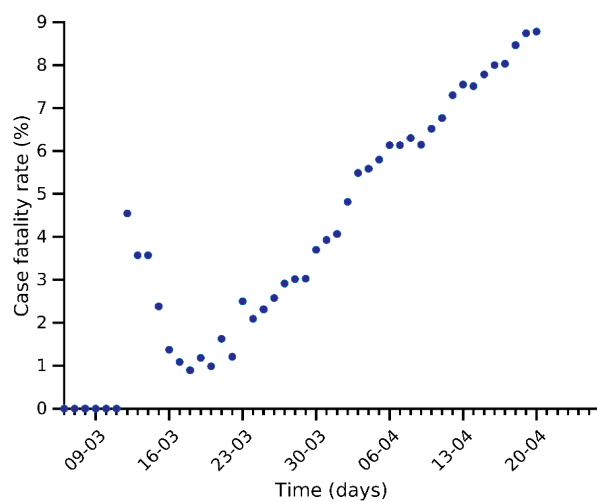
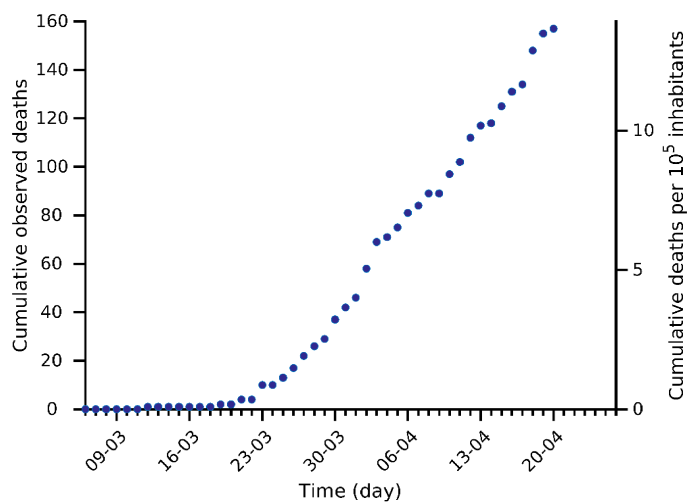
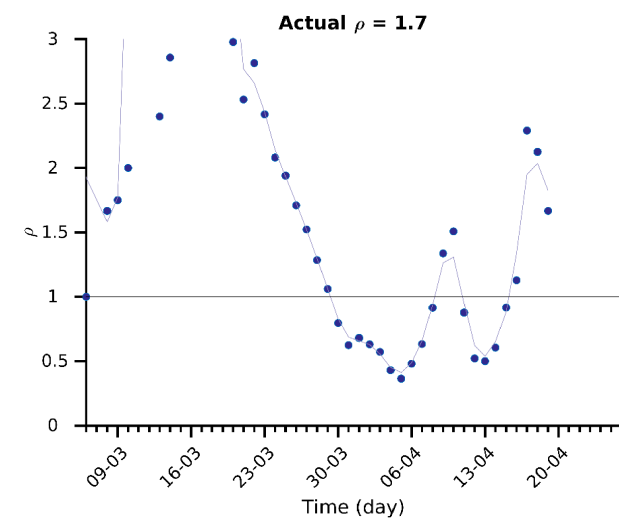
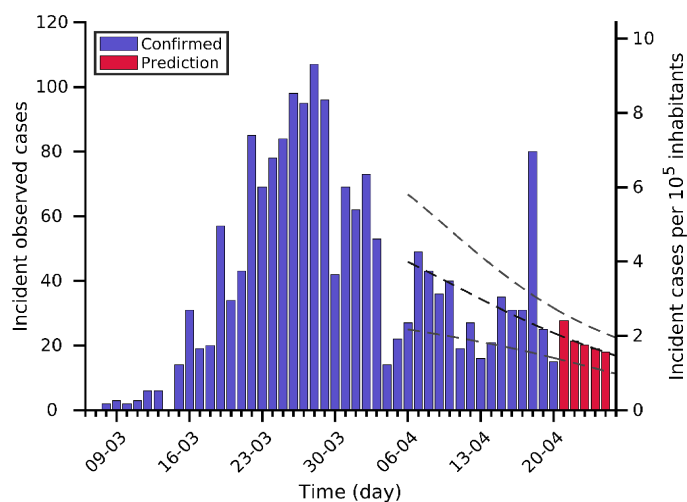
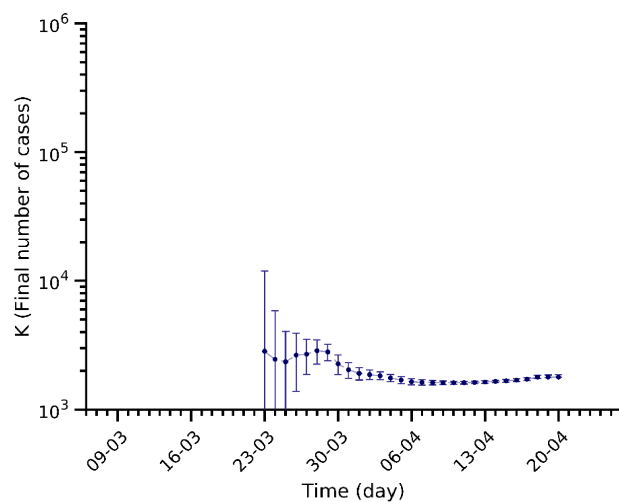
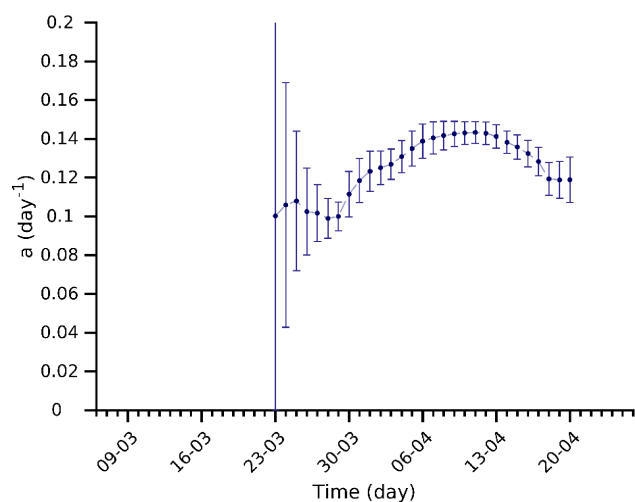
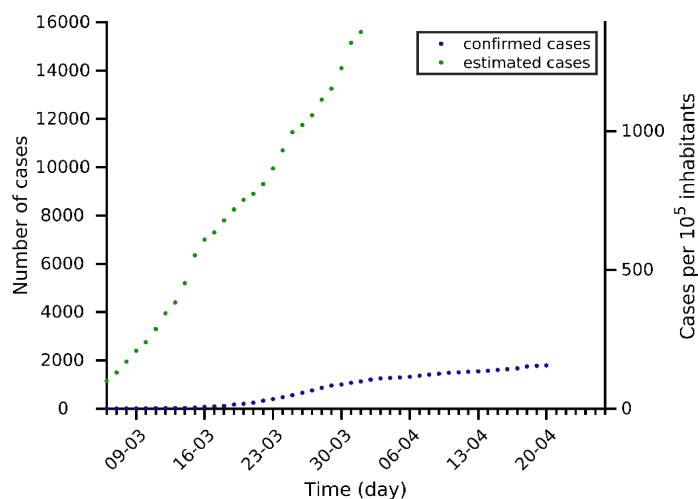
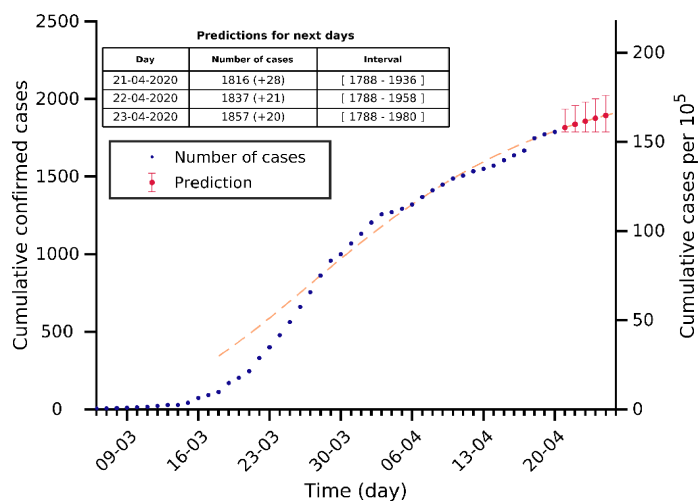
Cantabria 20-04-2020. Population: 0.6M. Current cumulated incidence: 358/10⁵



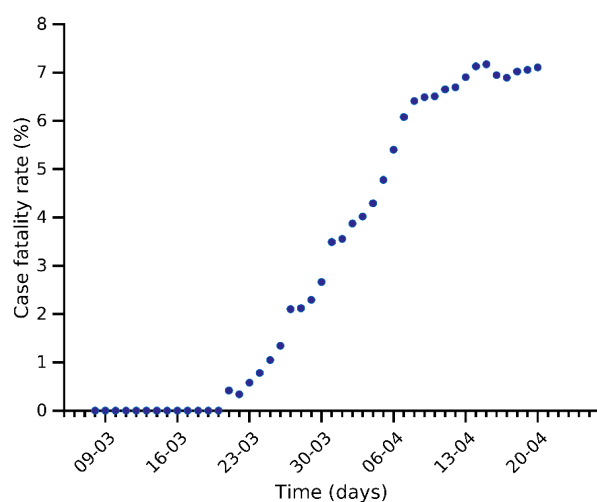
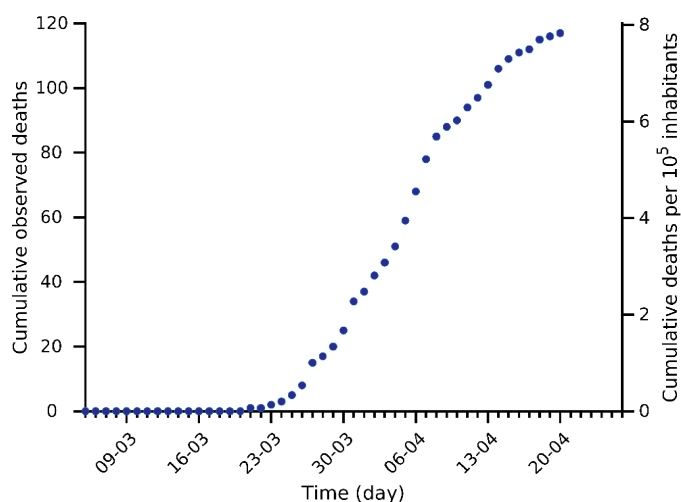
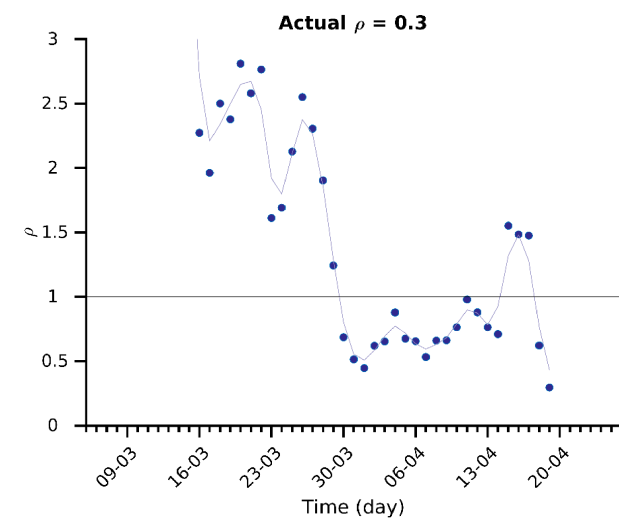
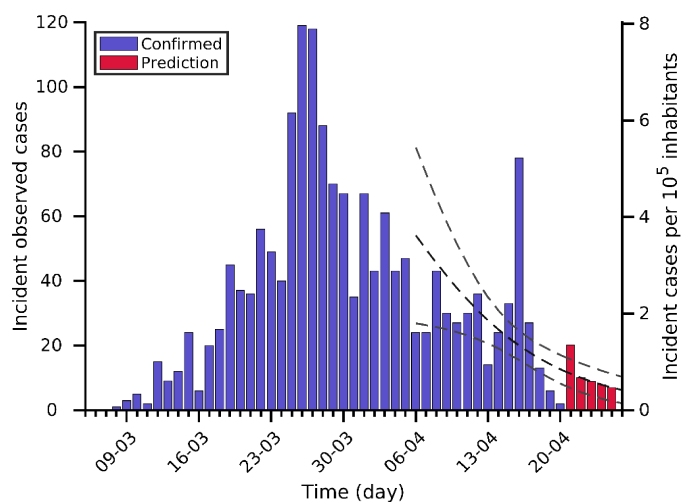
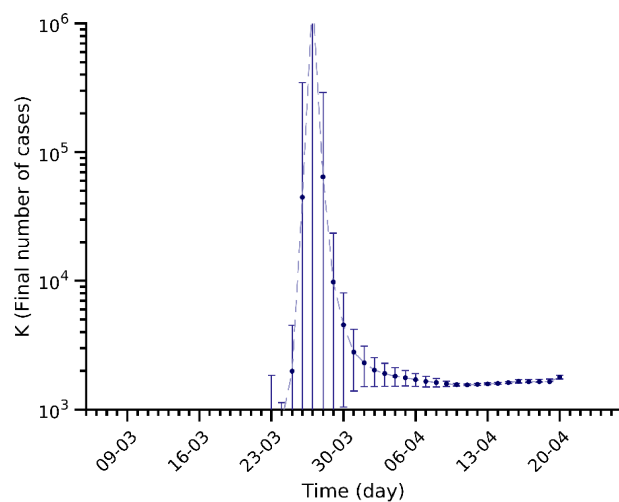
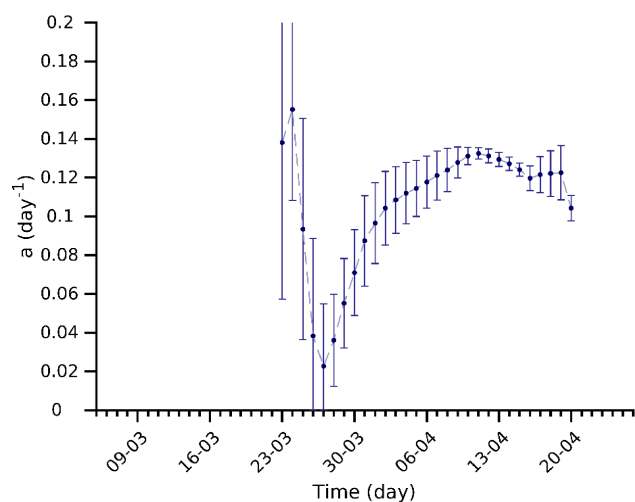
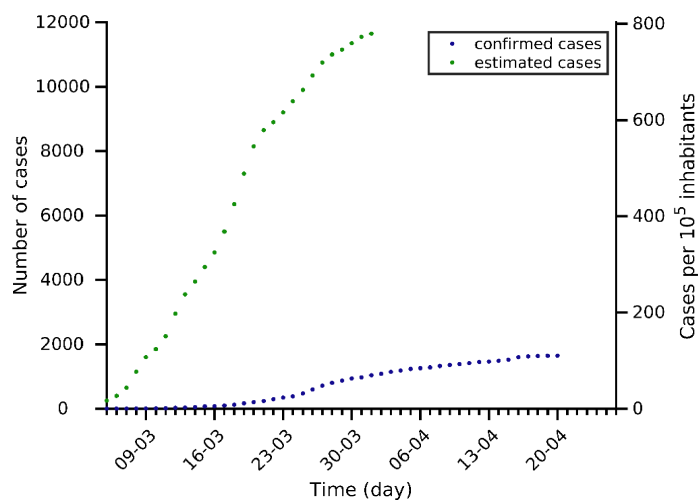
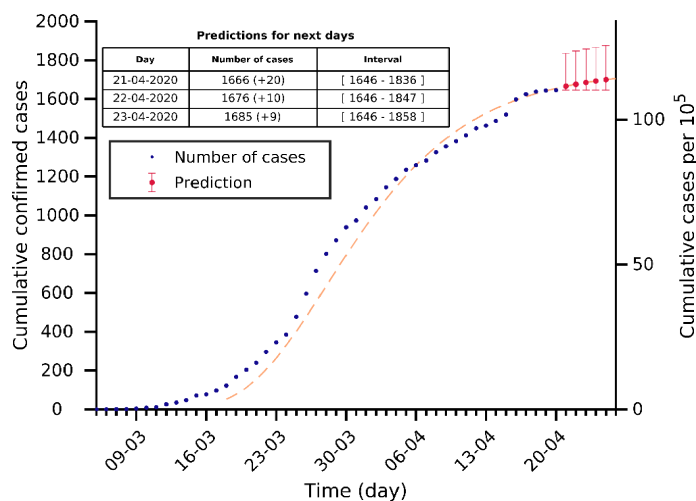
Canarias 20-04-2020. Population: 2.2M. Current cumulated incidence: 96/10⁵



Baleares 20-04-2020. Population: 1.1M. Current cumulated incidence: 156/10⁵



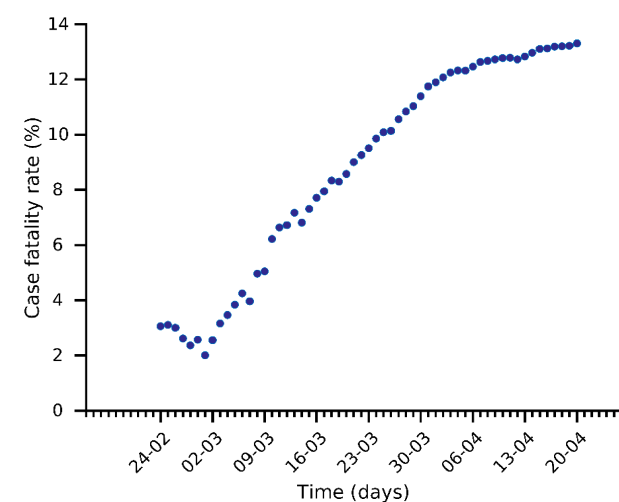
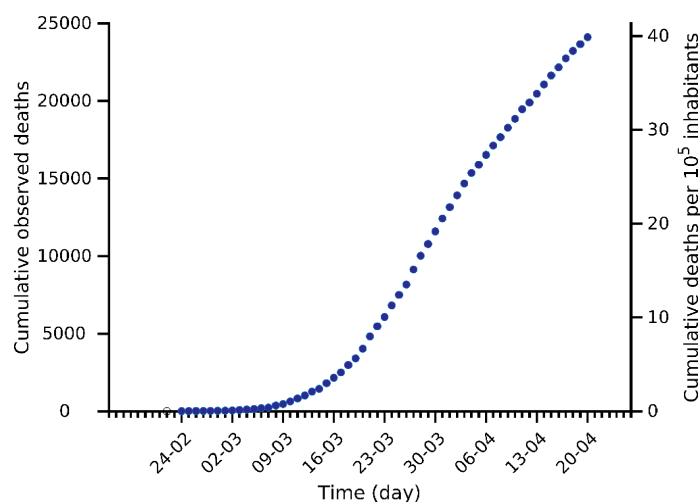
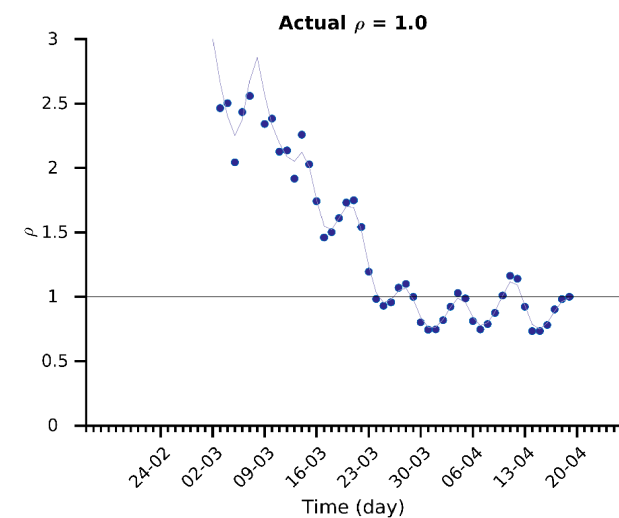
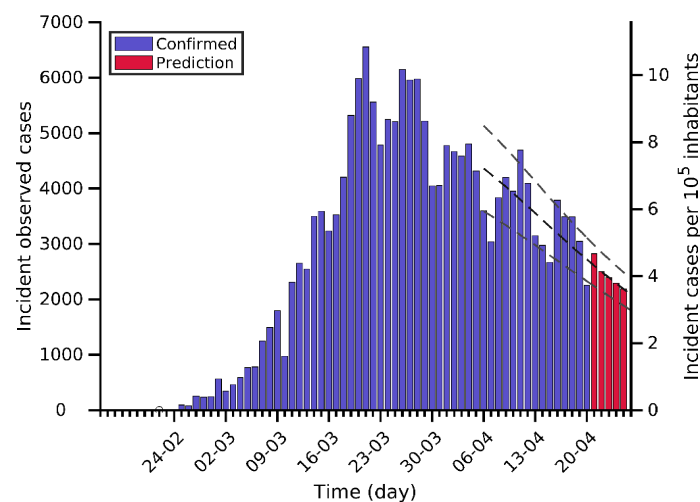
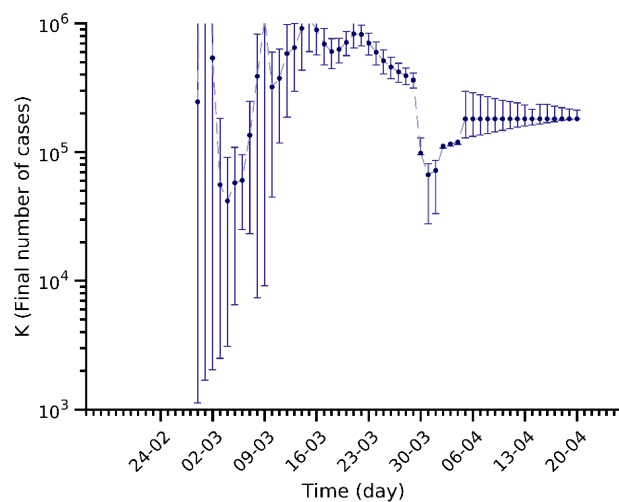
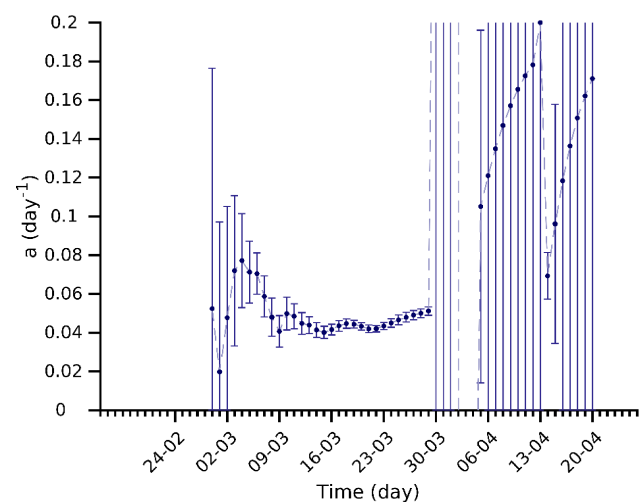
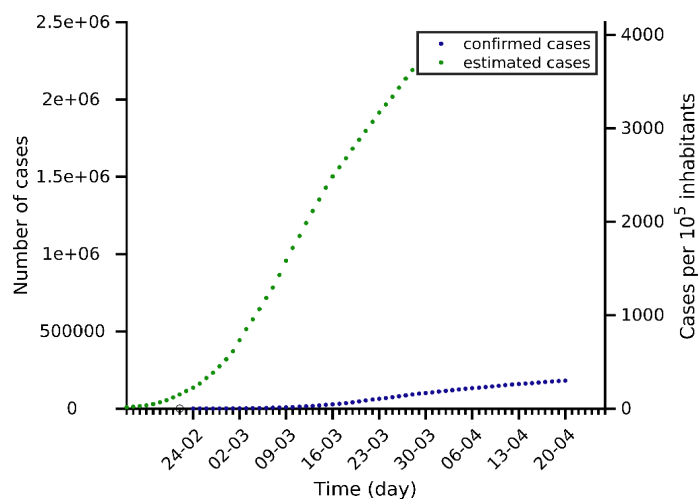
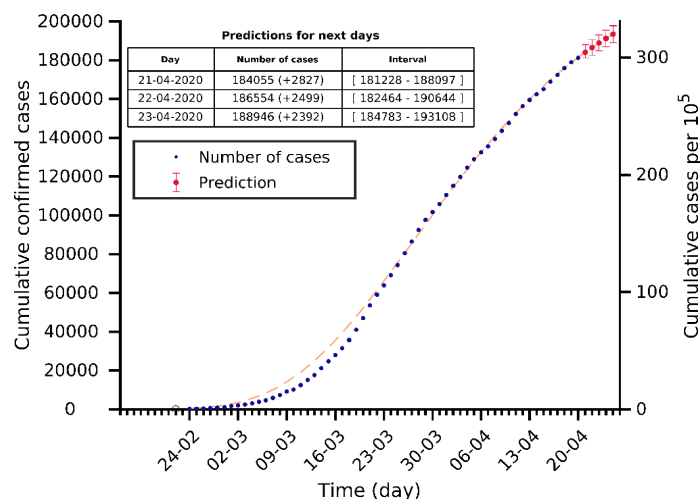
Murcia 20-04-2020. Population: 1.5M. Current cumulated incidence: 110/10⁵



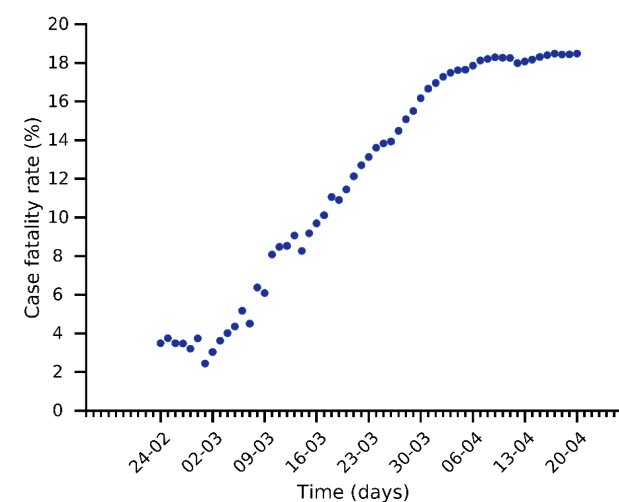
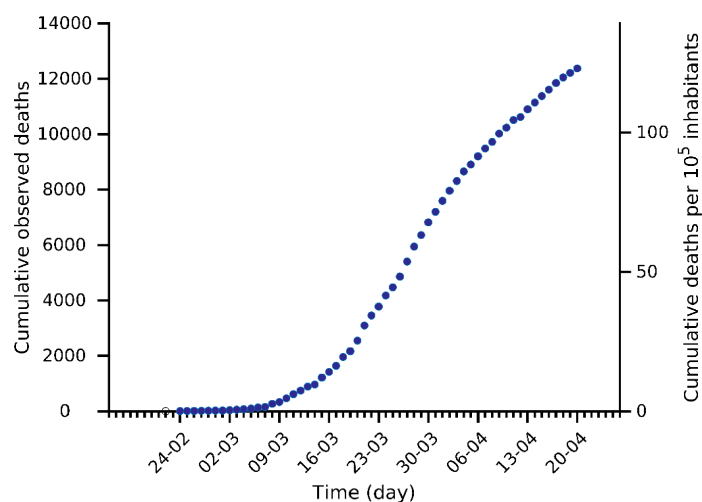
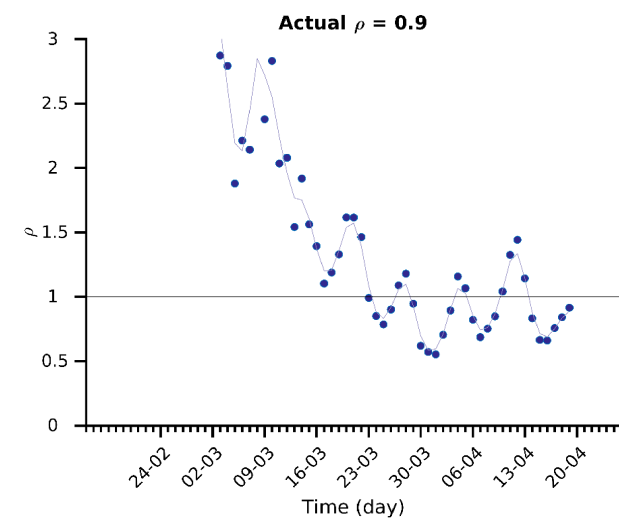
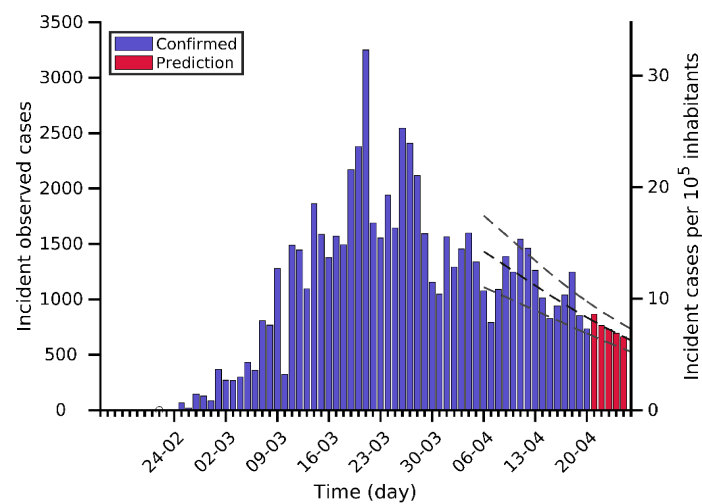
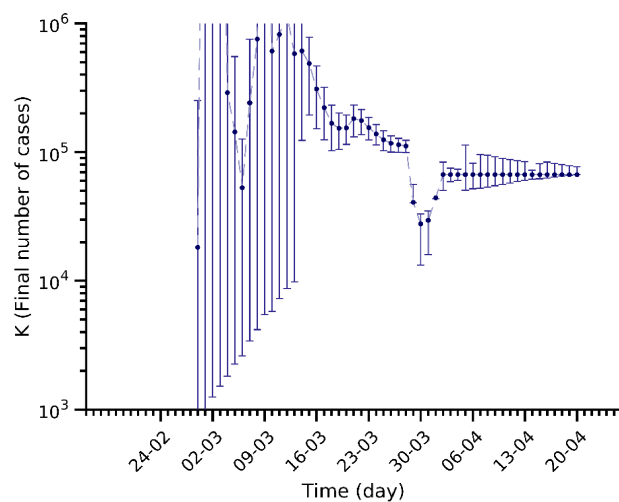
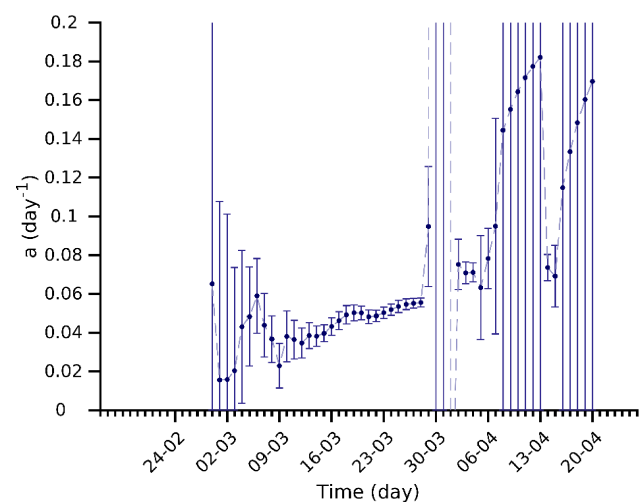
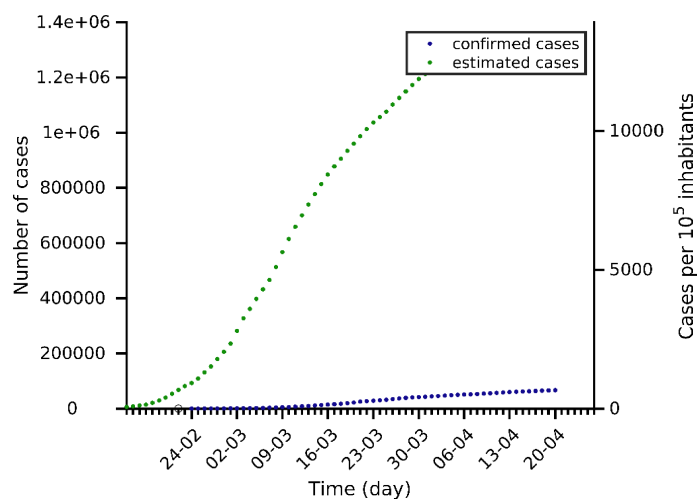
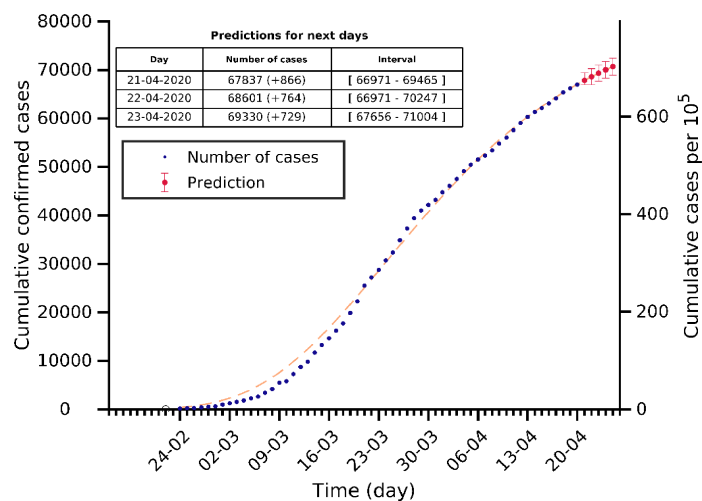
(4) Analysis and prediction of COVID-19 for Italy and its regions

Data obtained from: <https://github.com/pcm-dpc/COVID-19/tree/master/dati-andamento-nazionale>

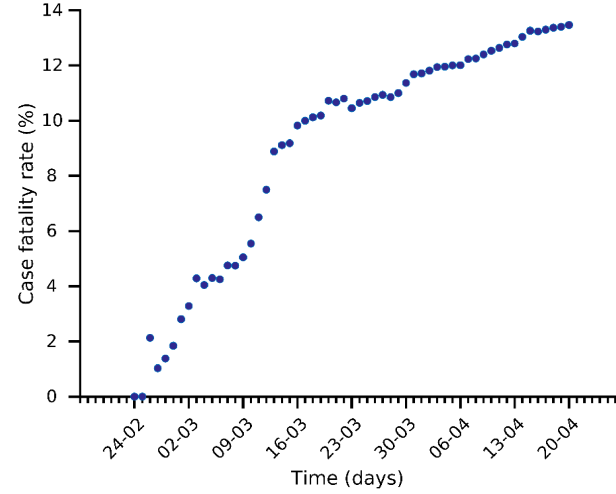
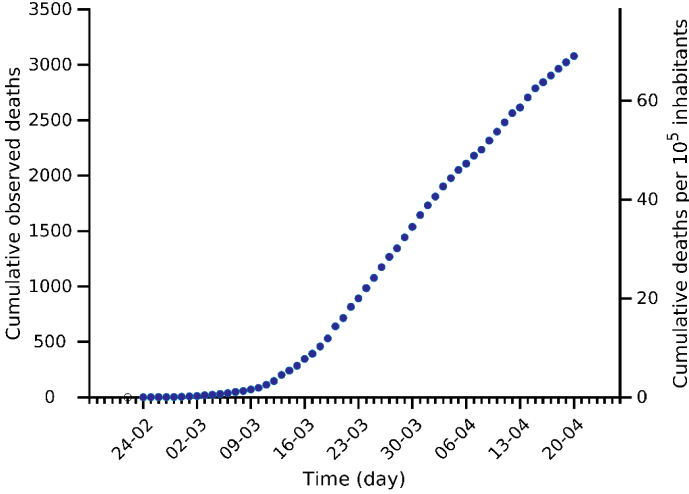
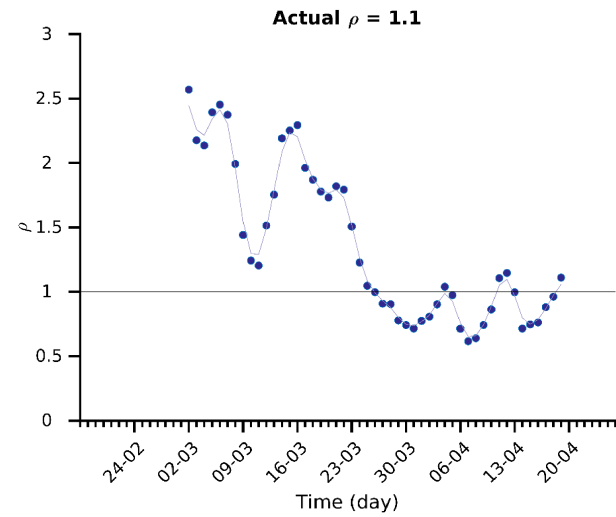
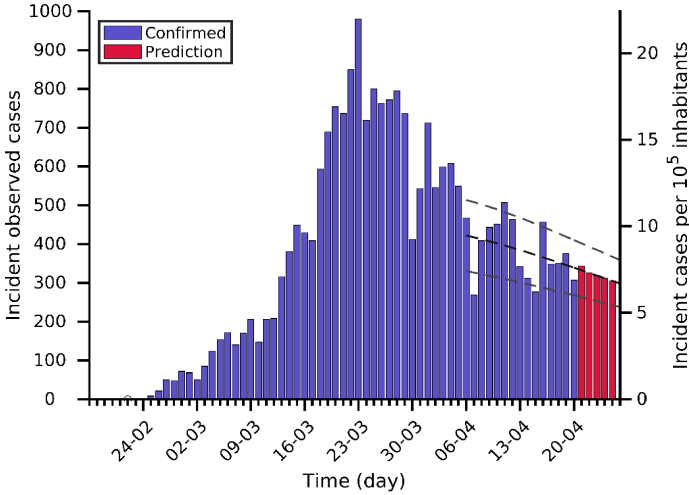
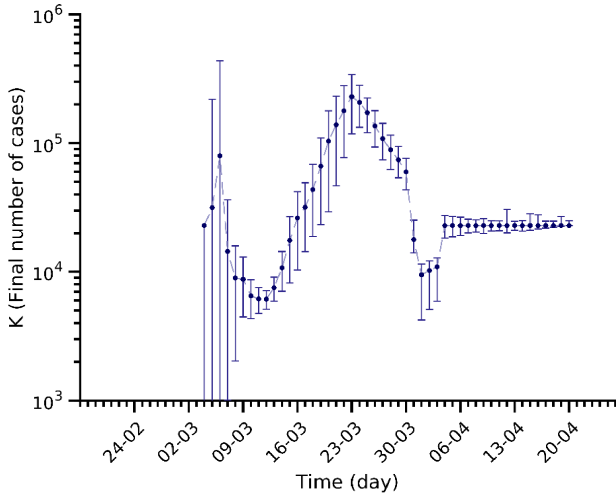
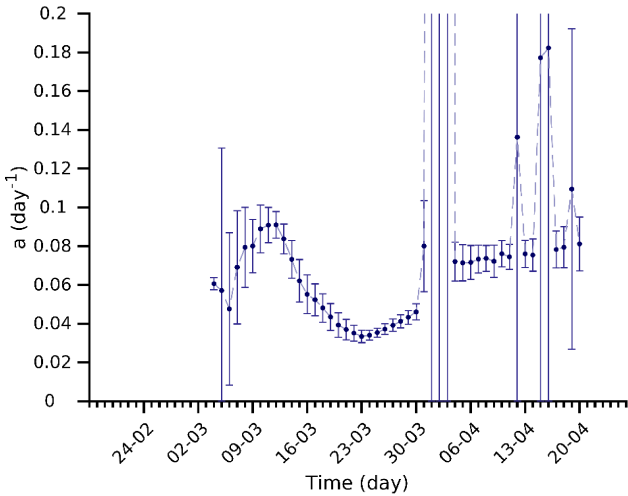
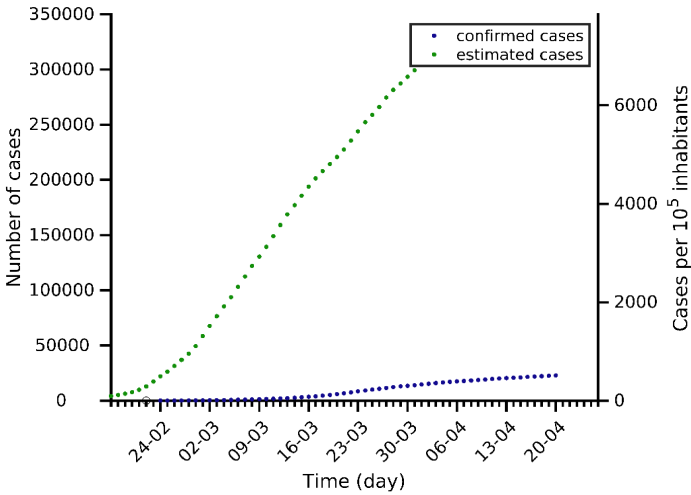
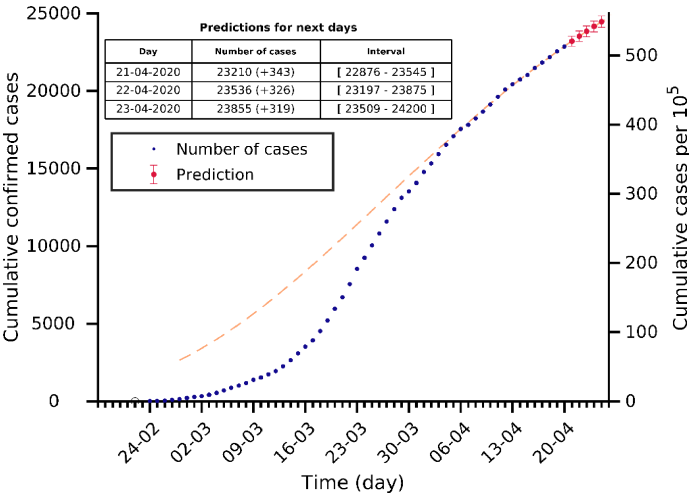
Italy 20-04-2020. Population: 60.5M. Current cumulated incidence: 300/10⁵



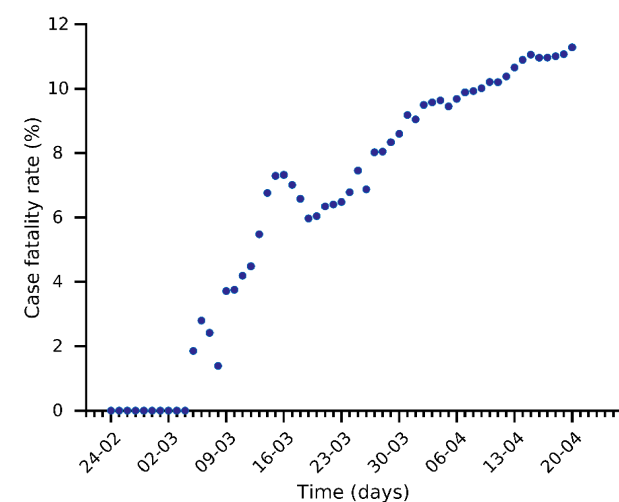
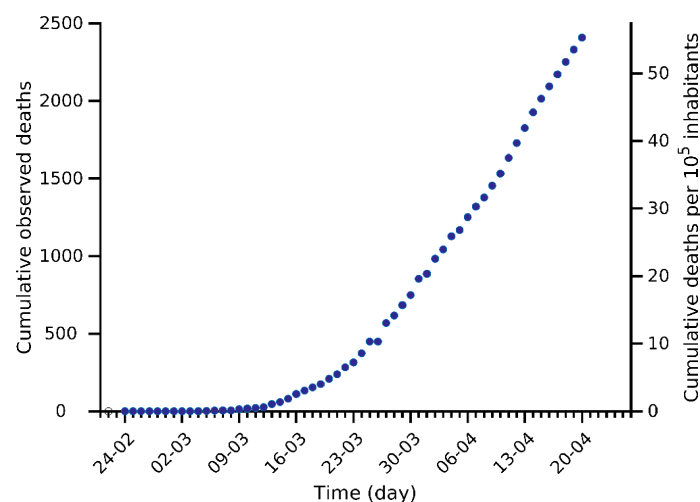
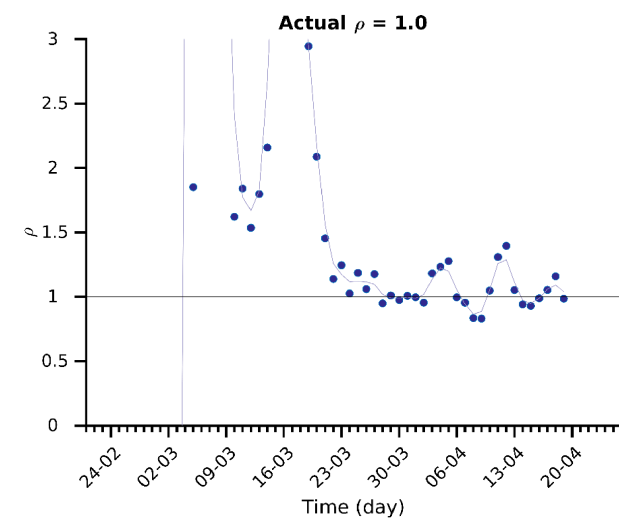
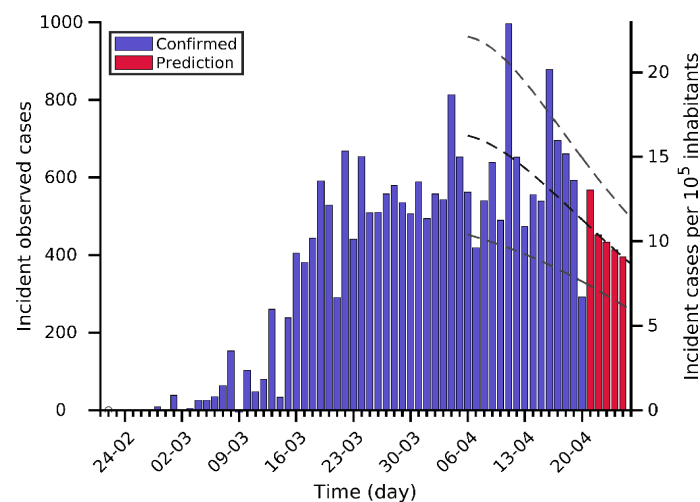
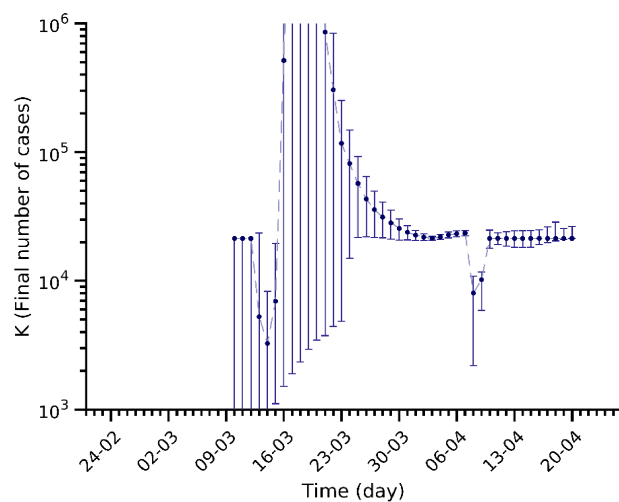
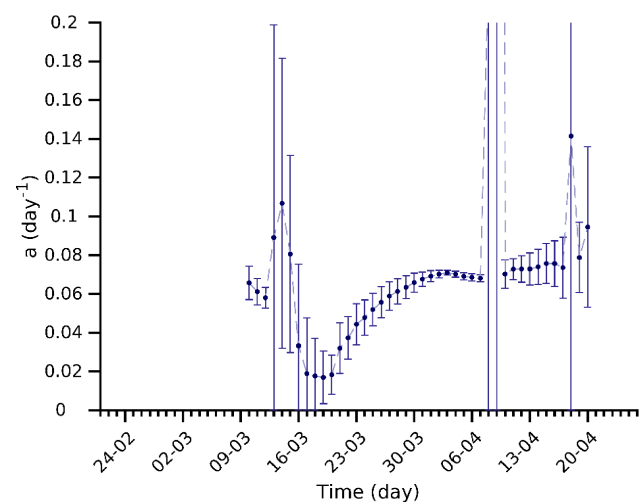
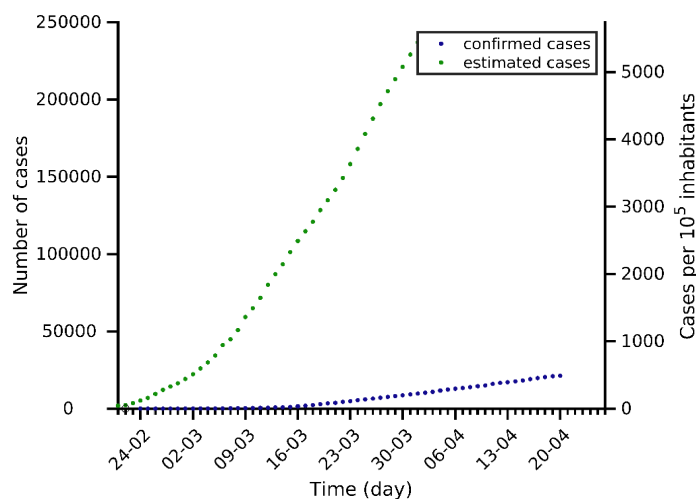
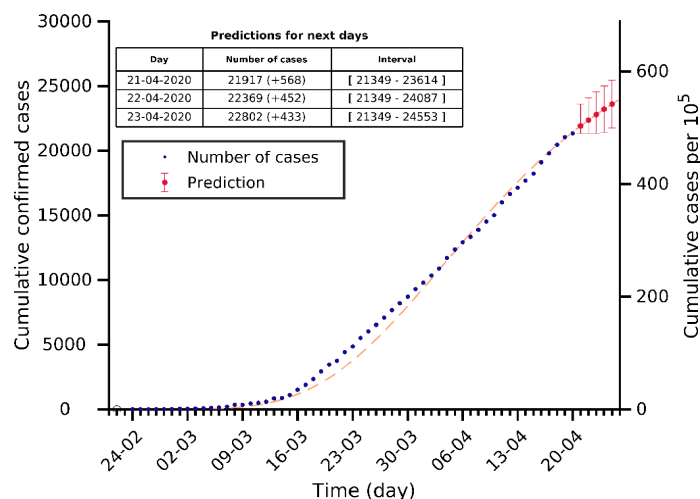
Lombardia 20-04-2020. Population: 10.1M. Current cumulated incidence: 666/10⁵



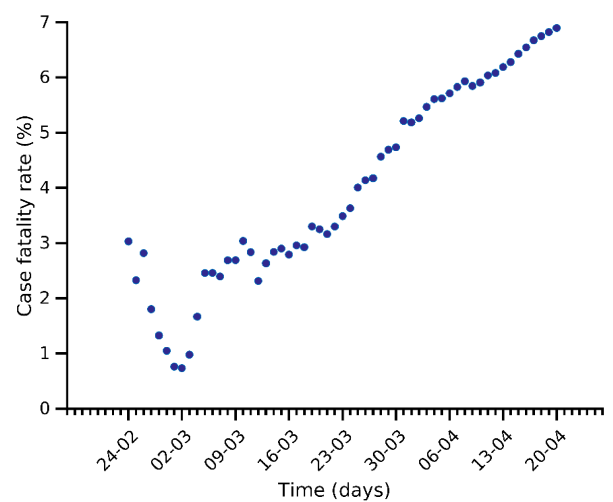
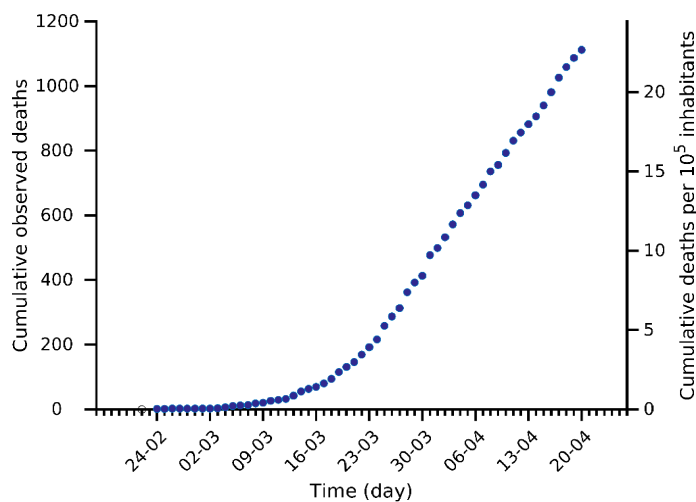
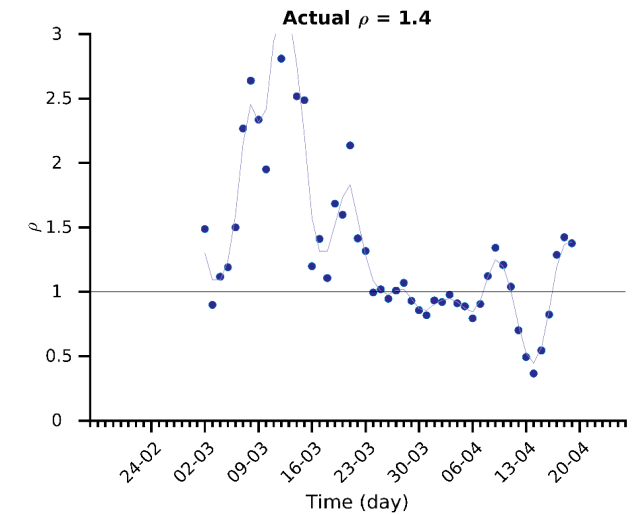
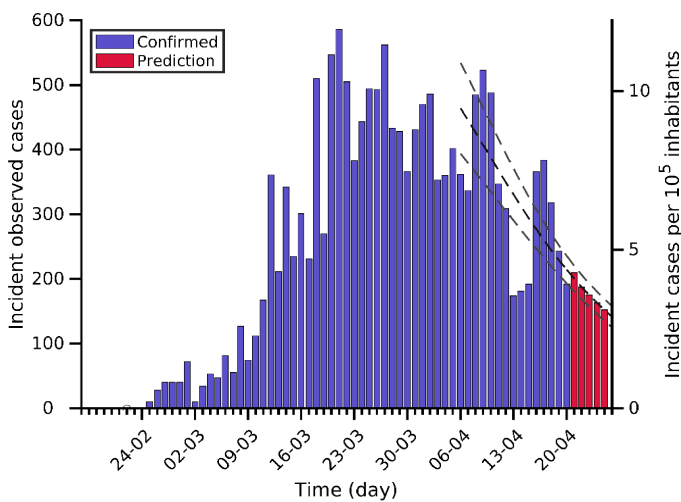
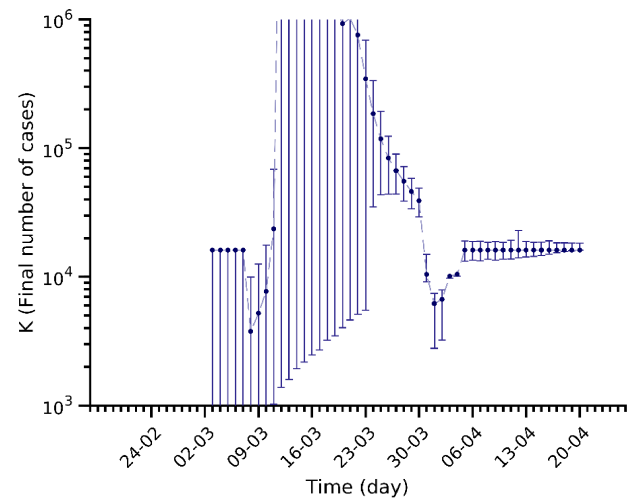
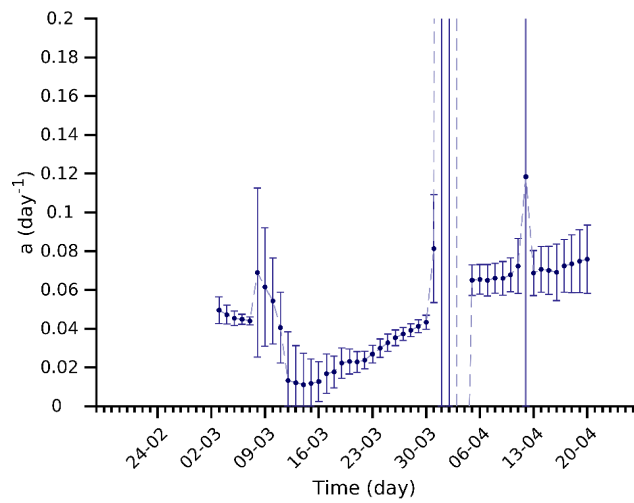
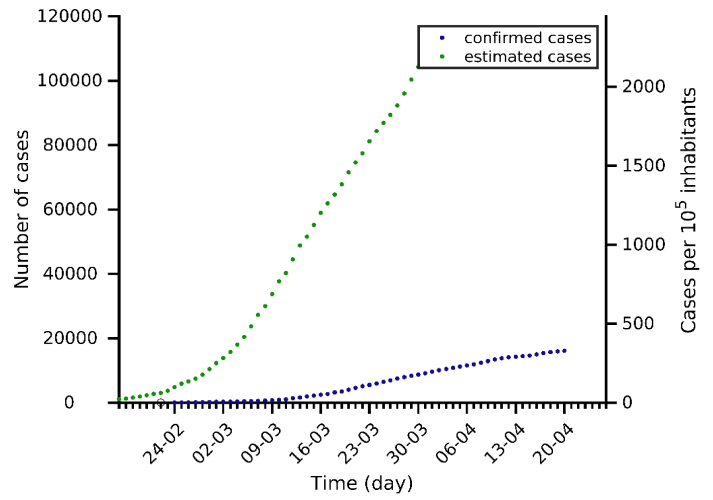
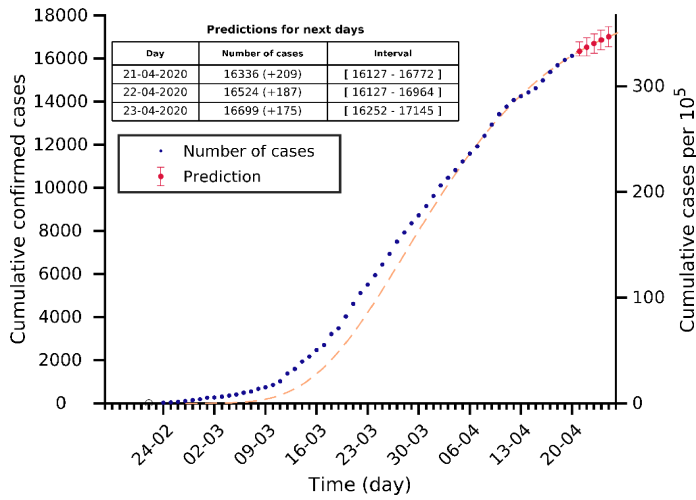
Emilia Romagna 20-04-2020. Population: 4.5M. Current cumulated incidence: 513/100,000



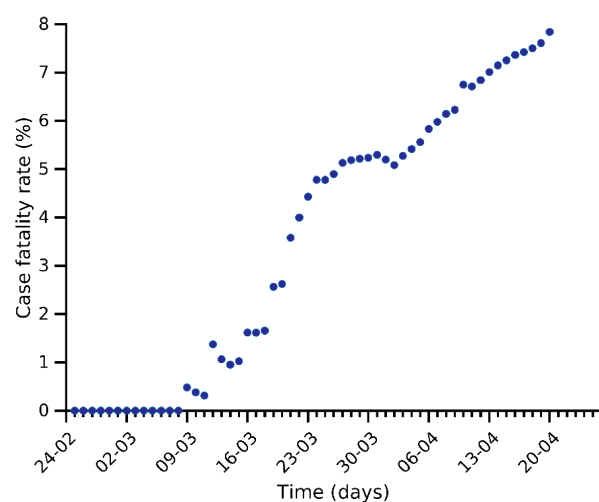
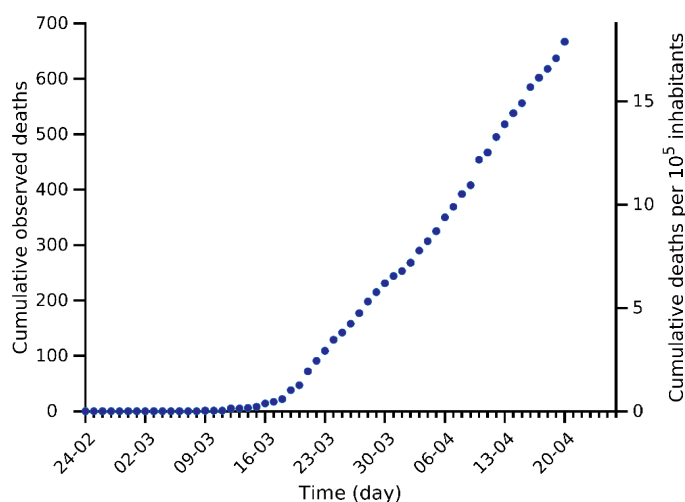
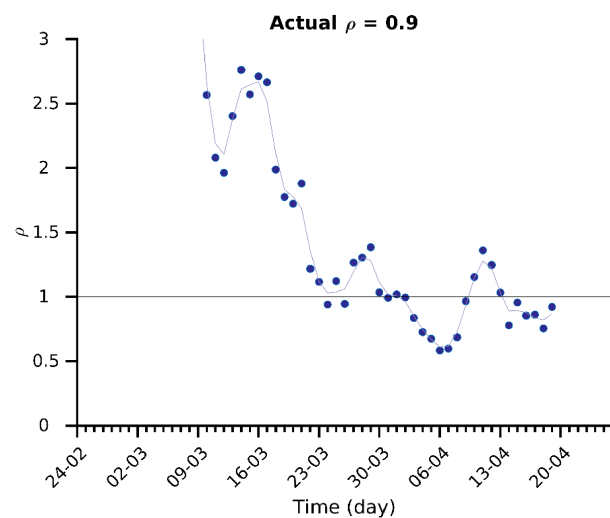
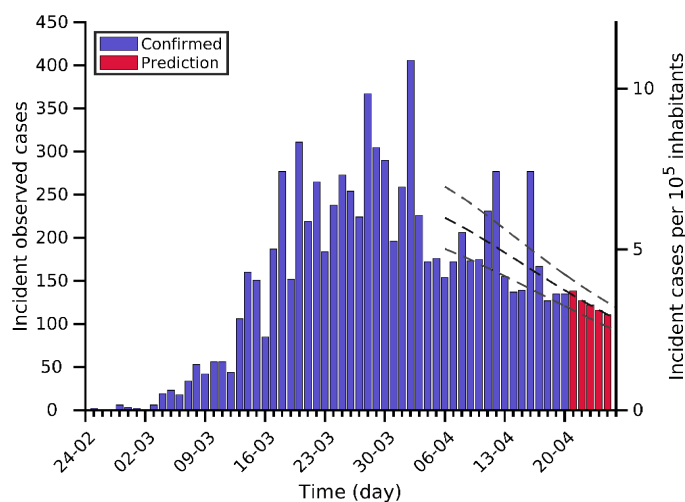
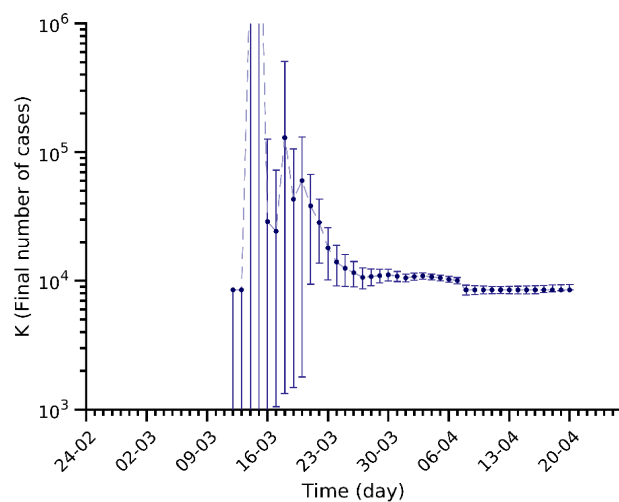
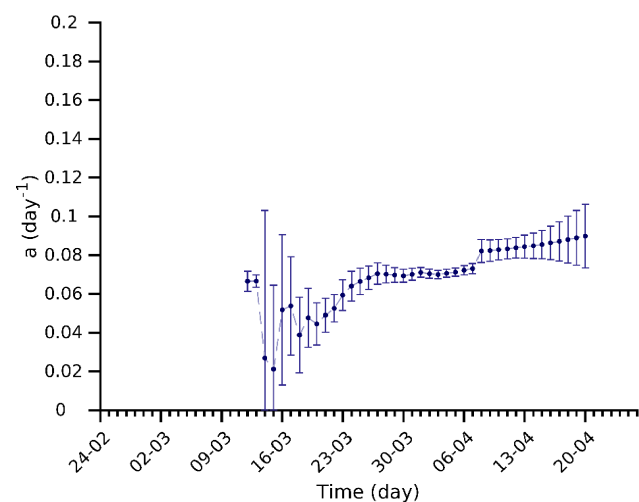
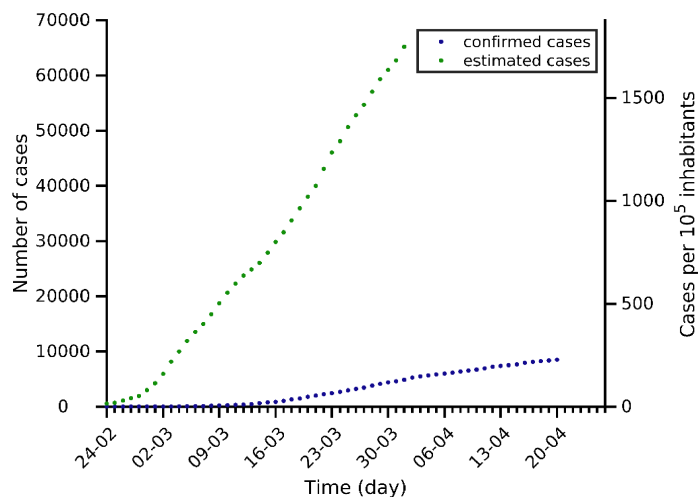
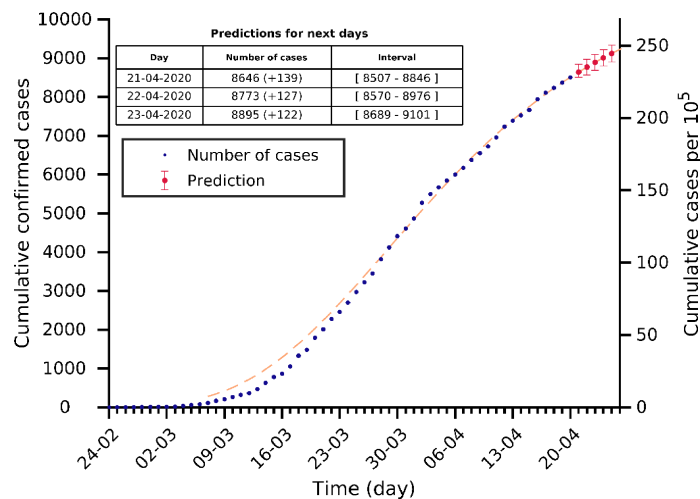
Piemonte 20-04-2020. Population: 4.4M. Current cumulated incidence: 490/10⁵



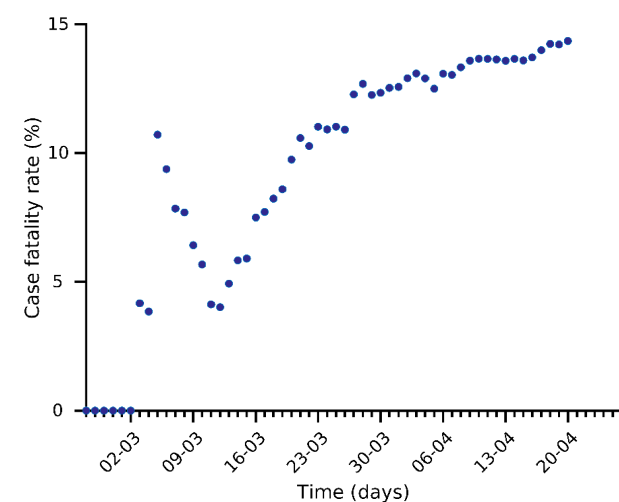
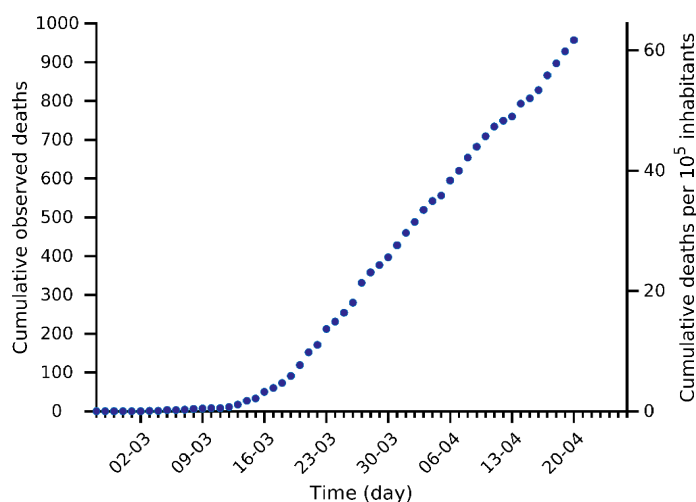
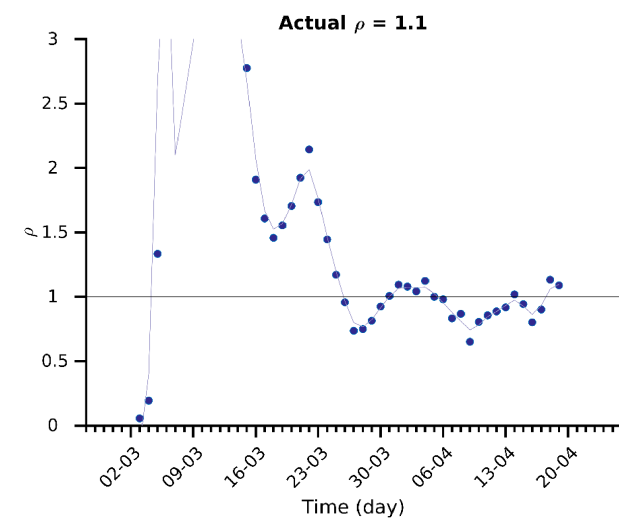
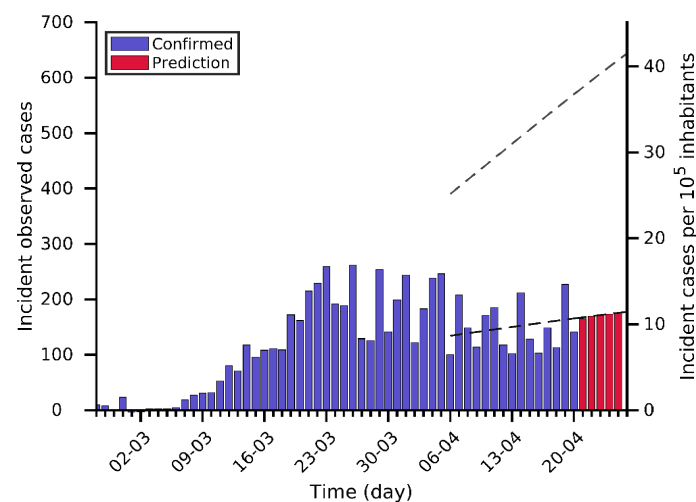
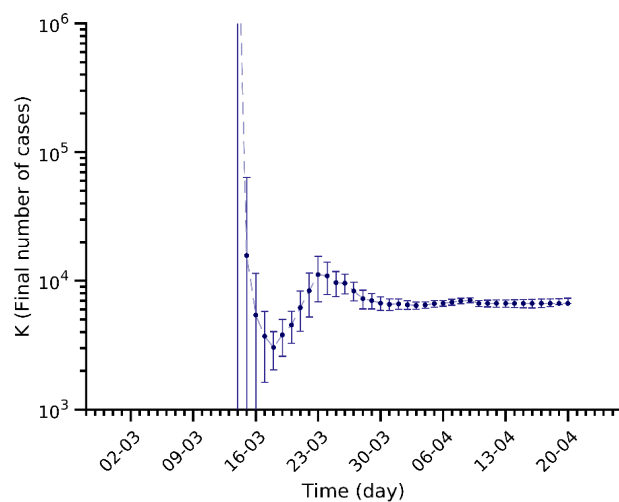
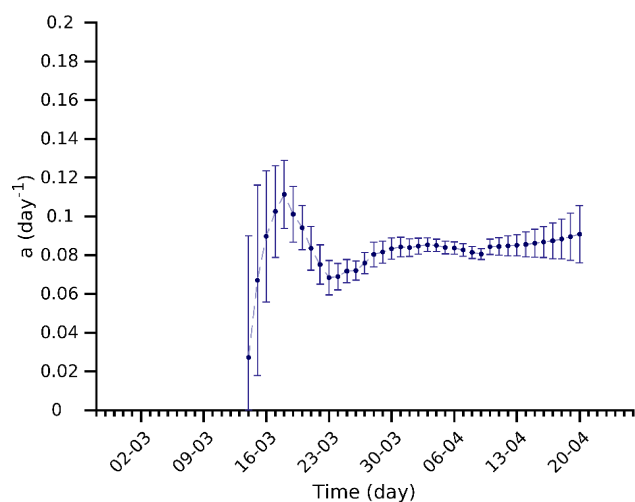
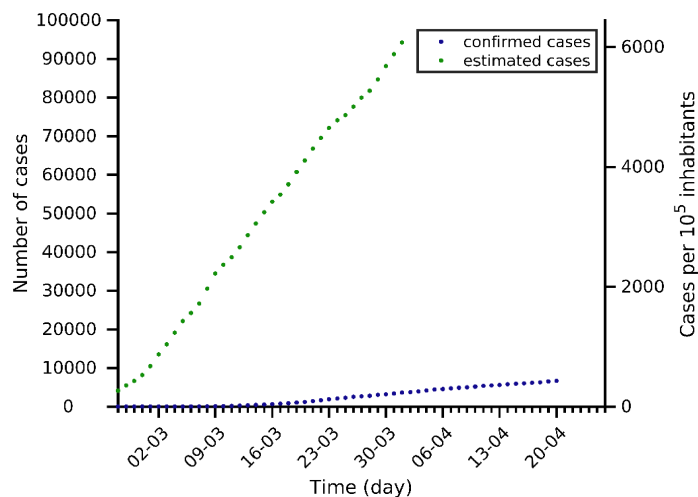
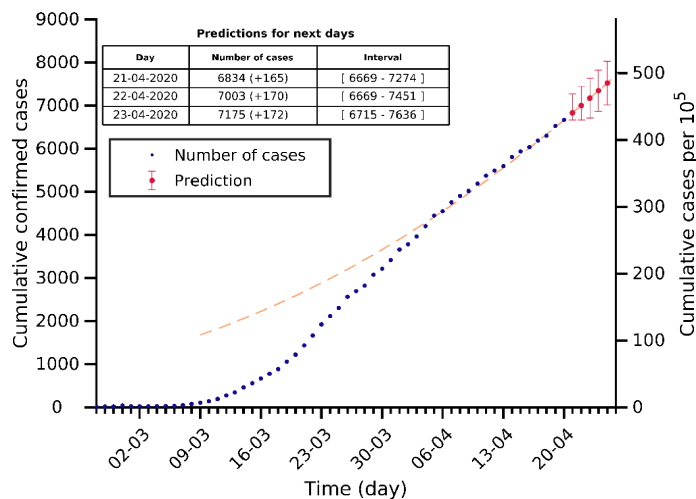
Veneto 20-04-2020. Population: 4.9M. Current cumulated incidence: 329/10⁵



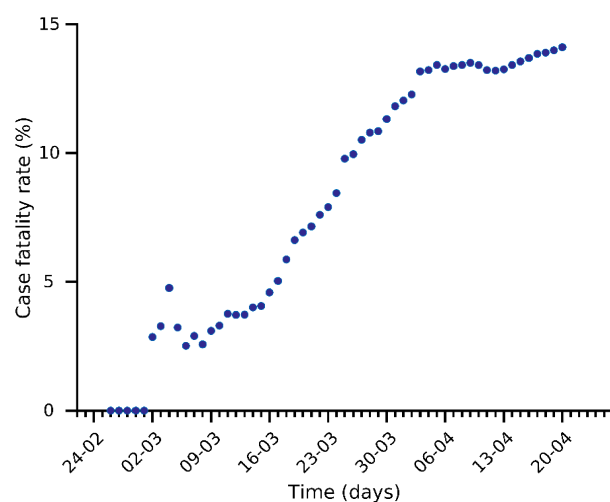
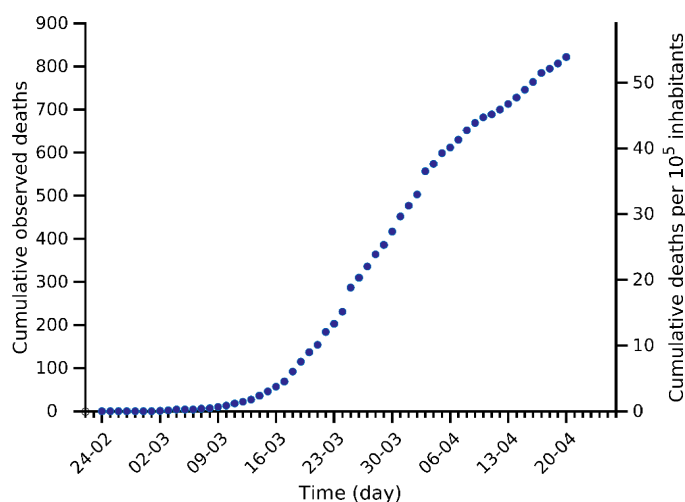
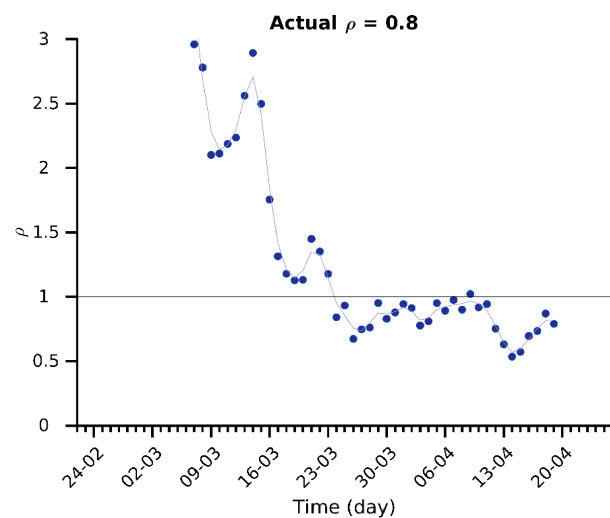
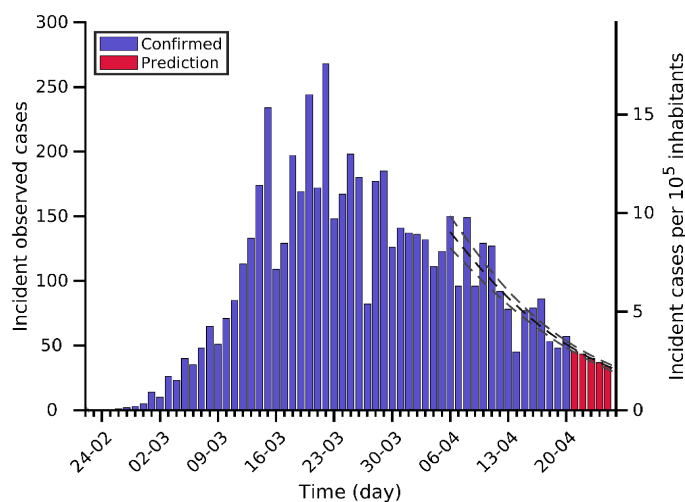
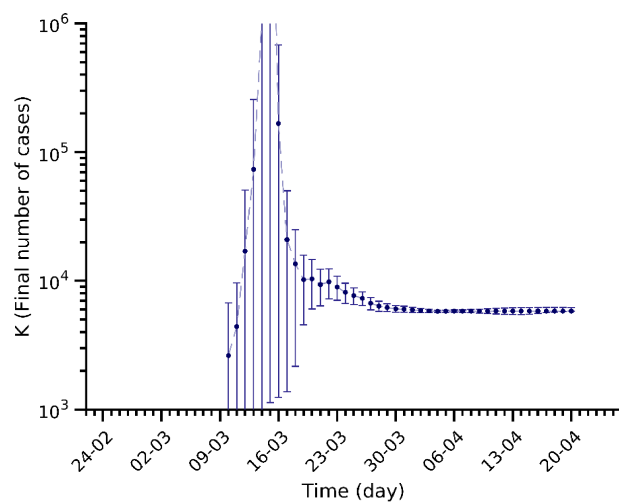
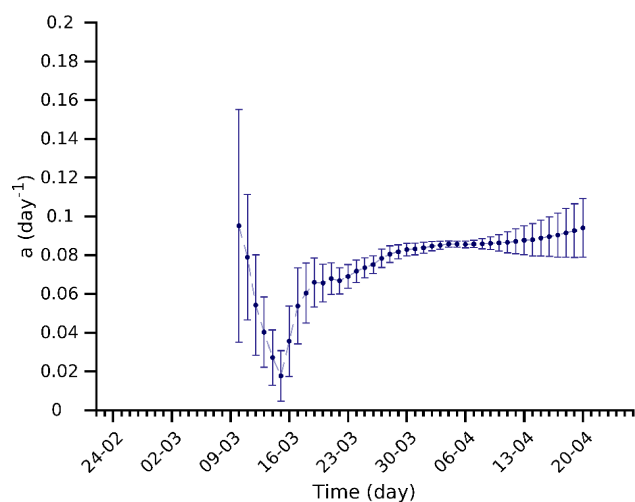
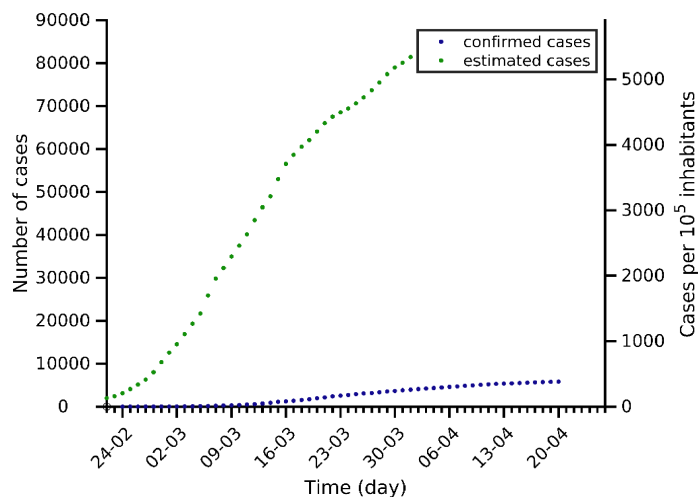
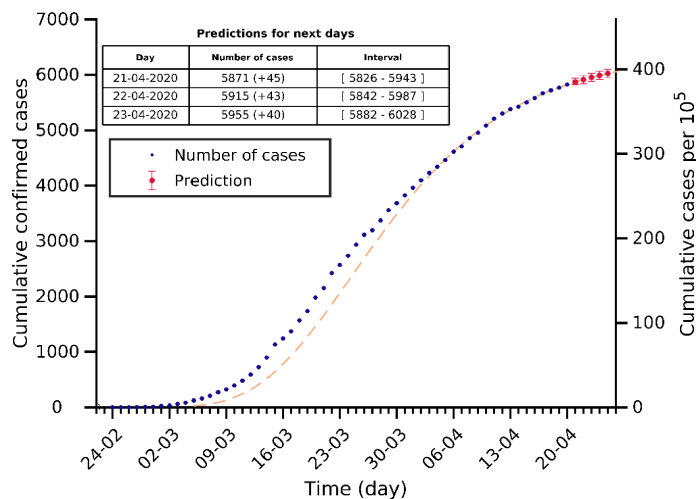
Toscana 20-04-2020. Population: 3.7M. Current cumulated incidence: 228/10⁵



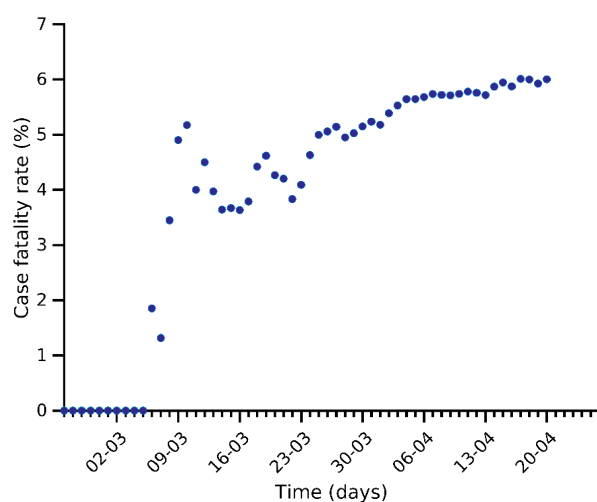
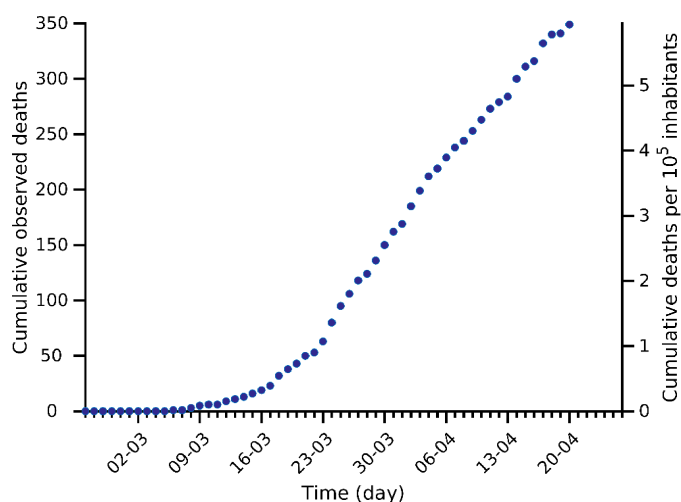
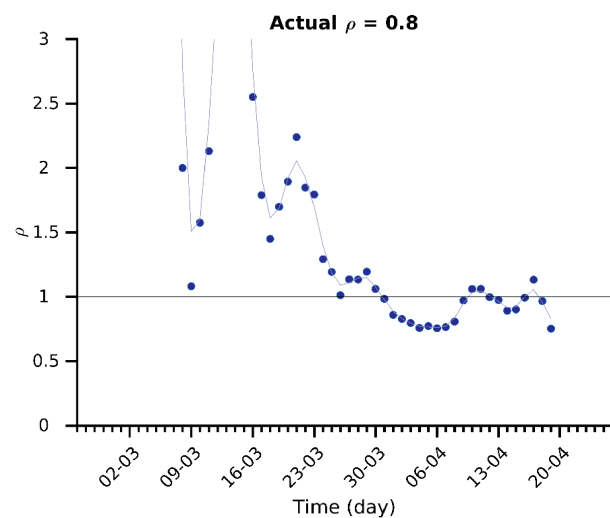
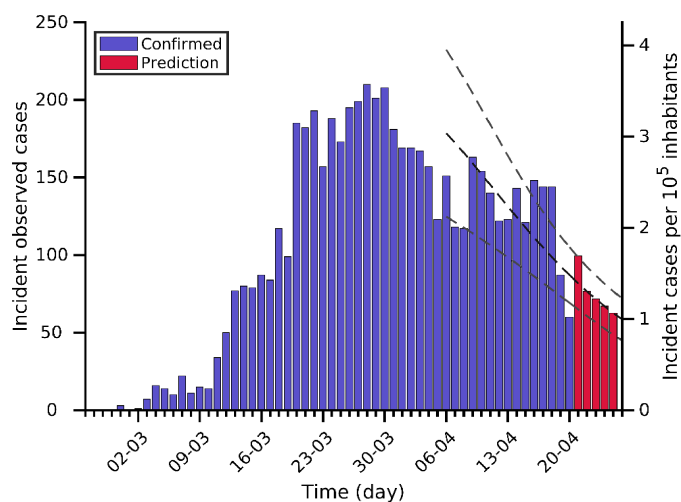
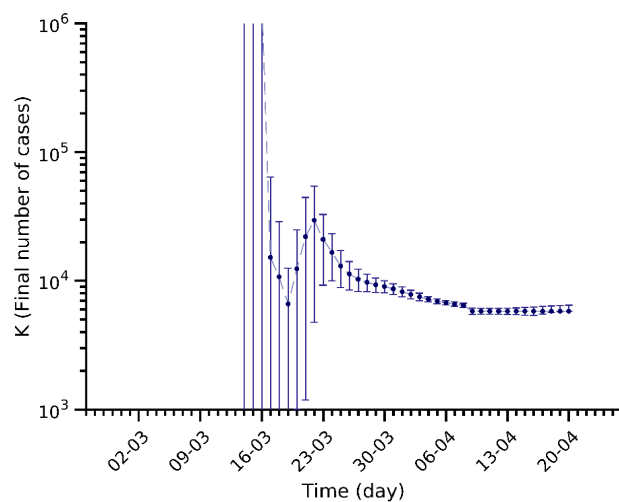
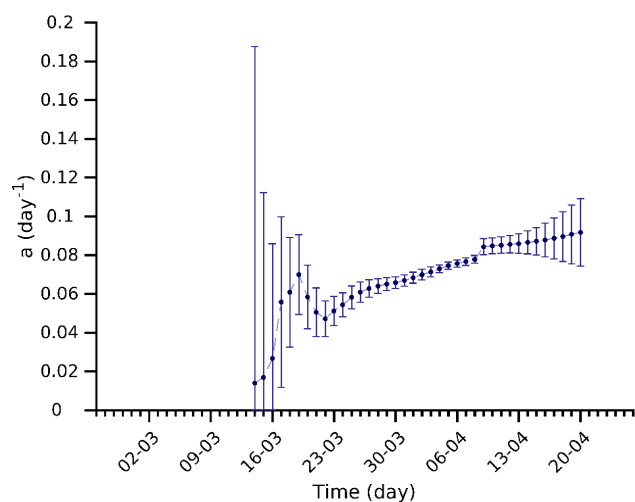
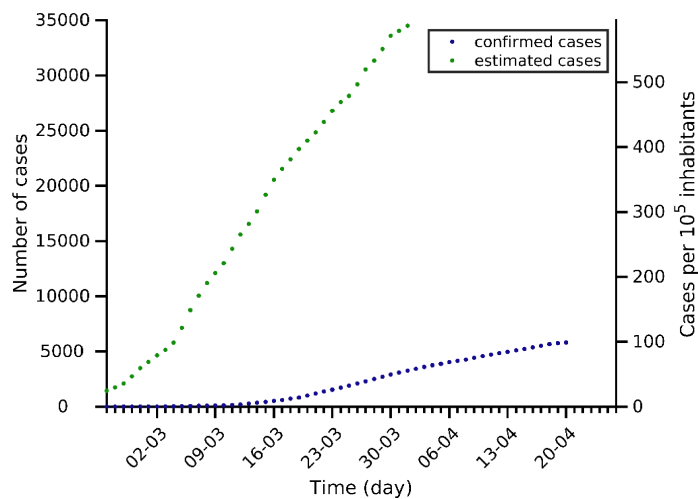
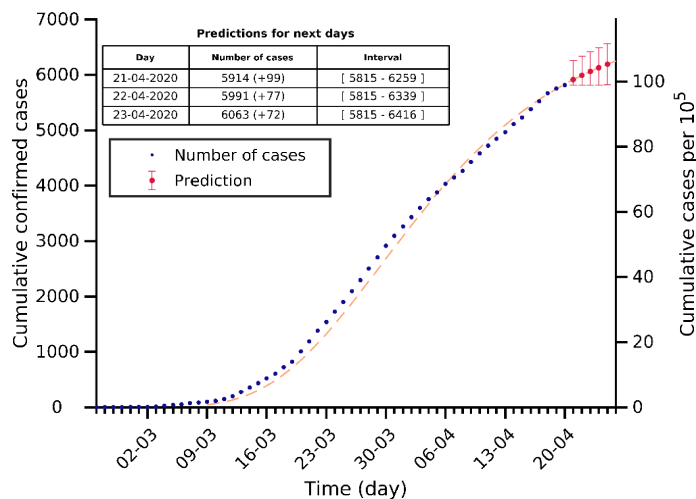
Liguria 20-04-2020. Population: 1.6M. Current cumulated incidence: 430/10⁵



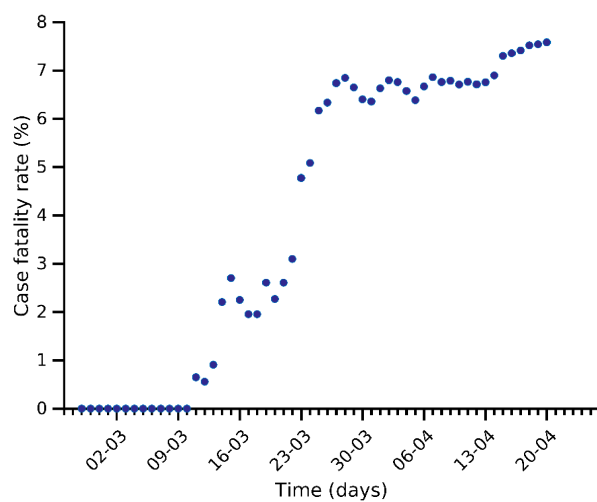
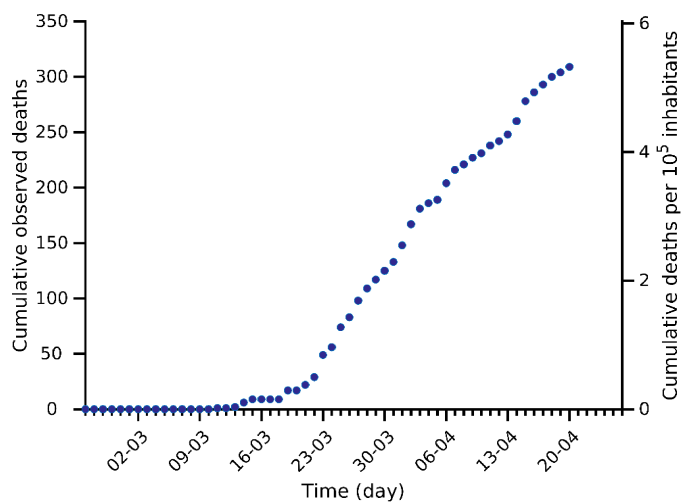
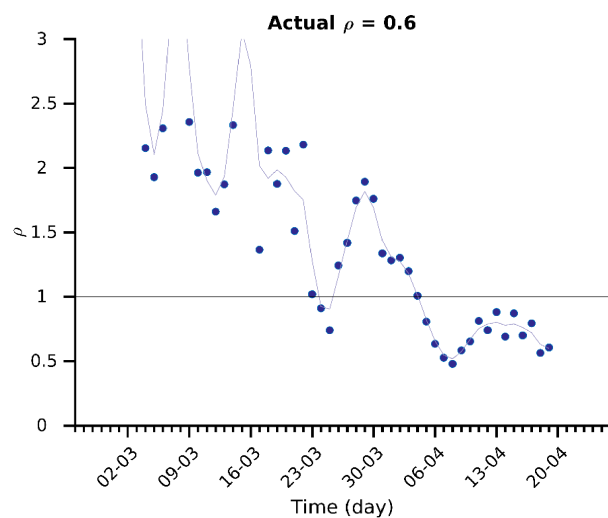
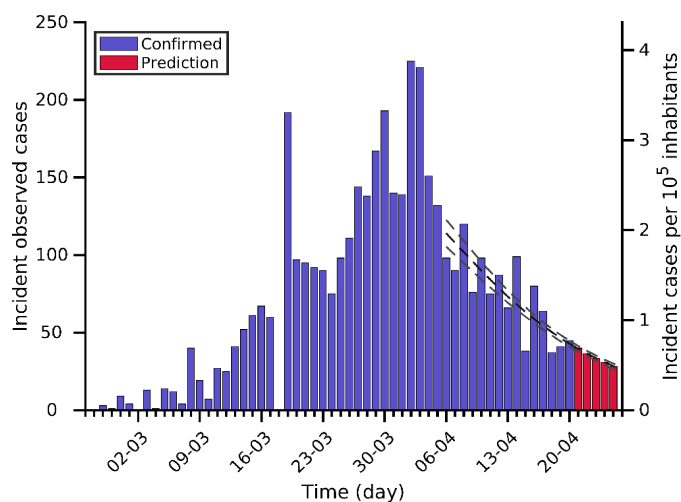
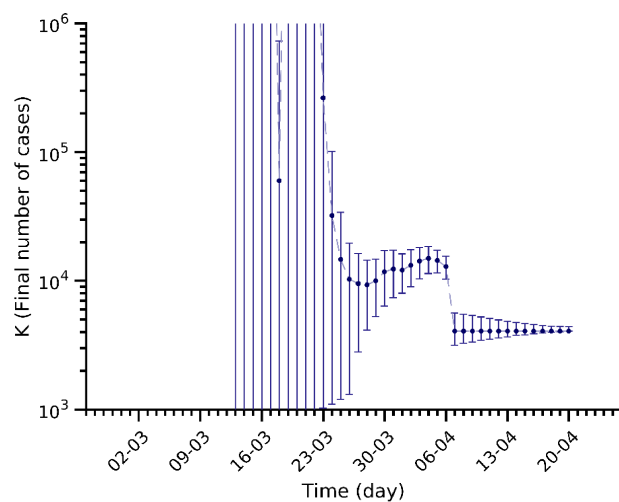
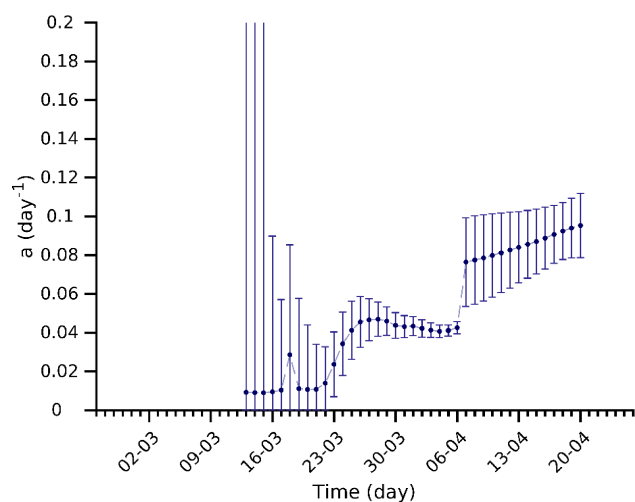
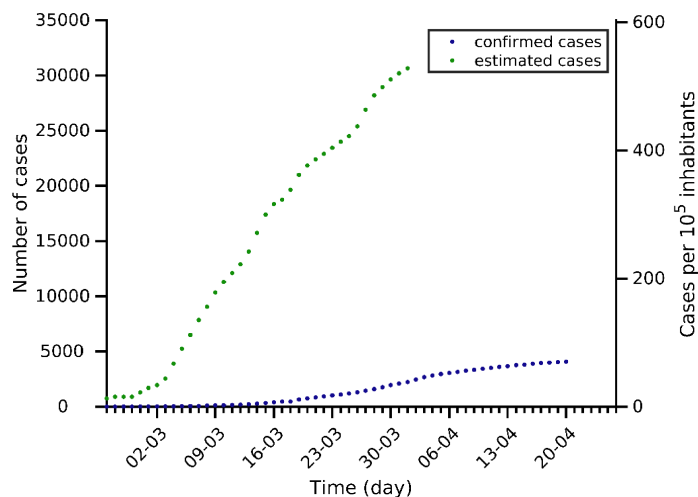
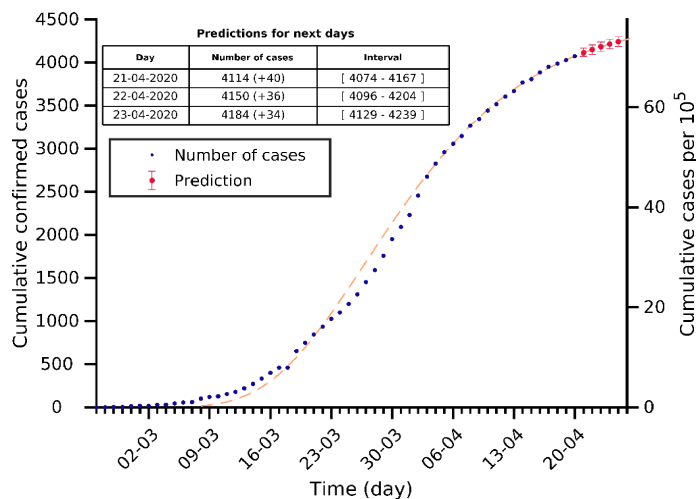
Marche 20-04-2020. Population: 1.5M. Current cumulated incidence: 382/10⁵



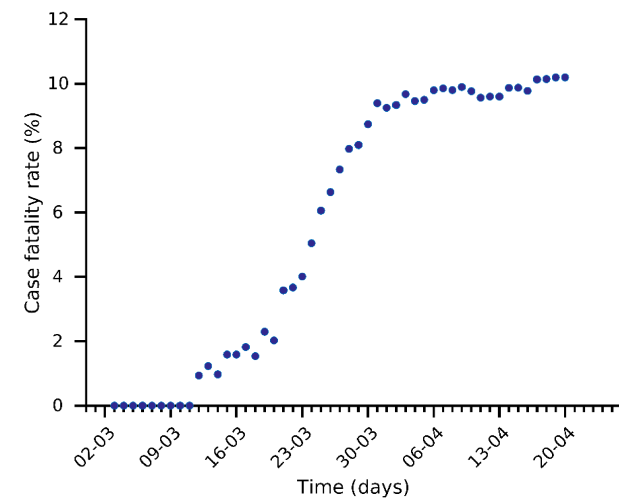
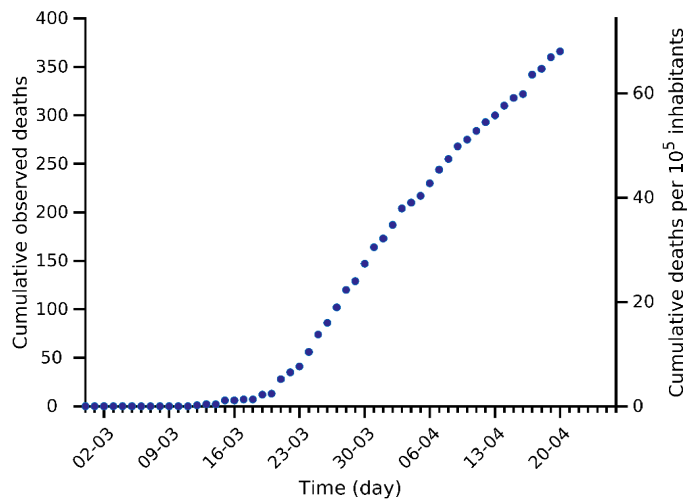
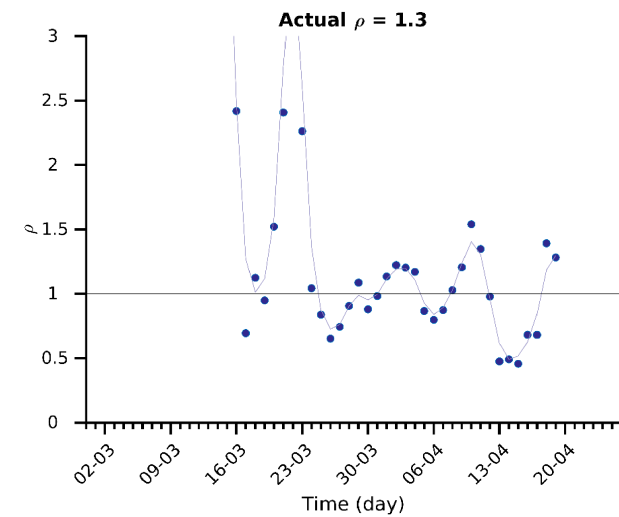
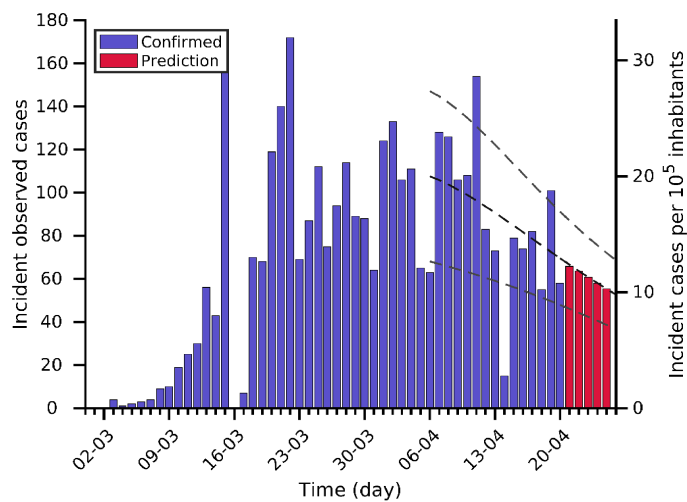
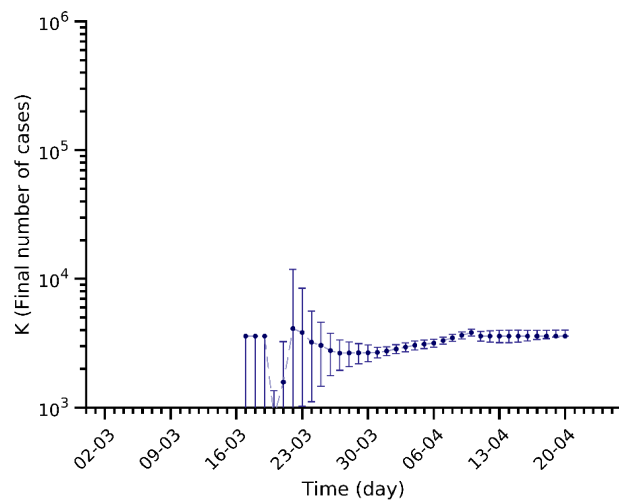
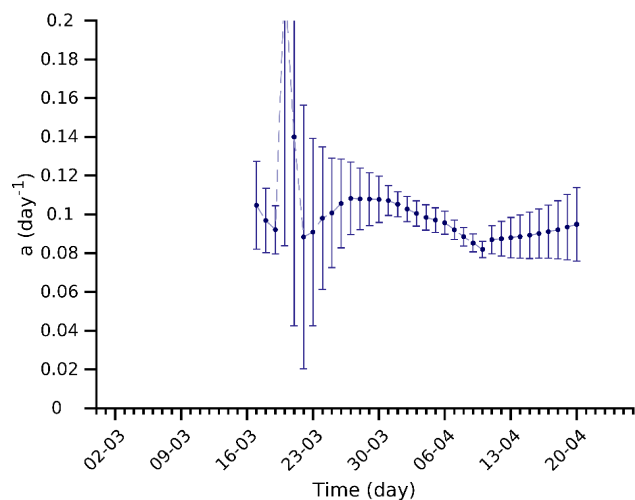
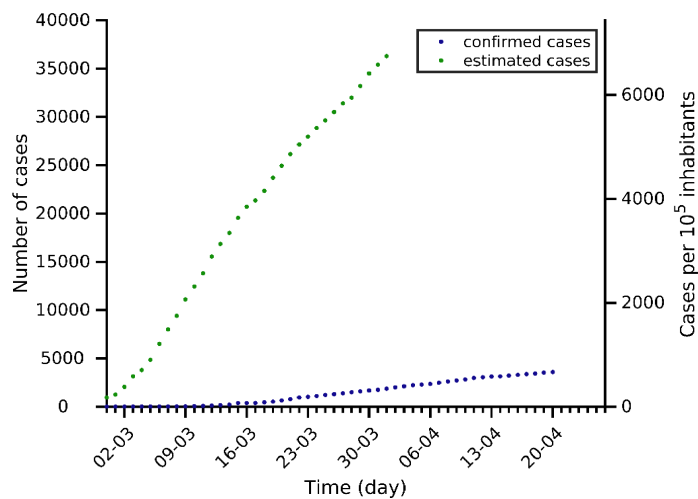
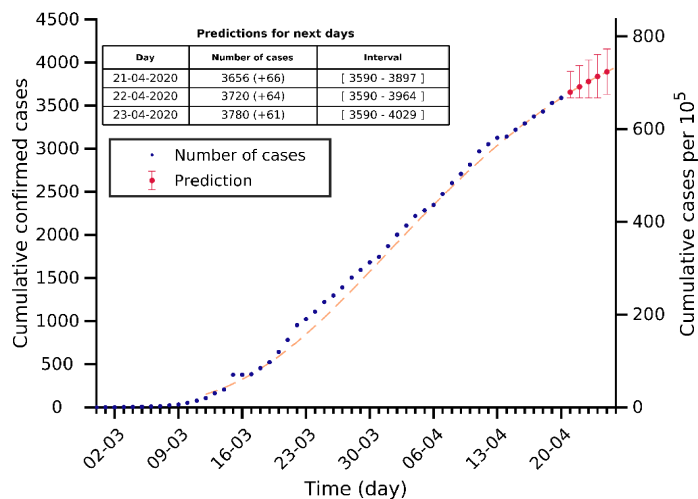
Lazio 20-04-2020. Population: 5.9M. Current cumulated incidence: 99/10⁵



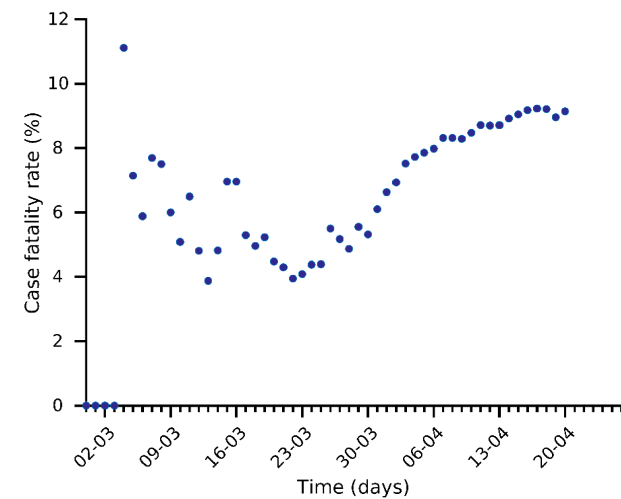
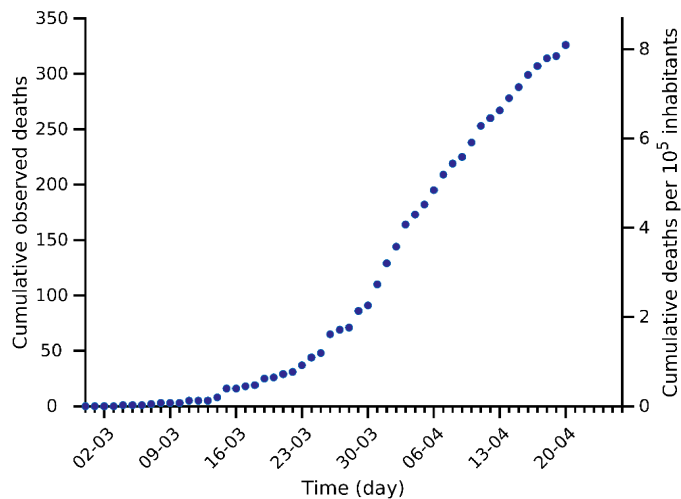
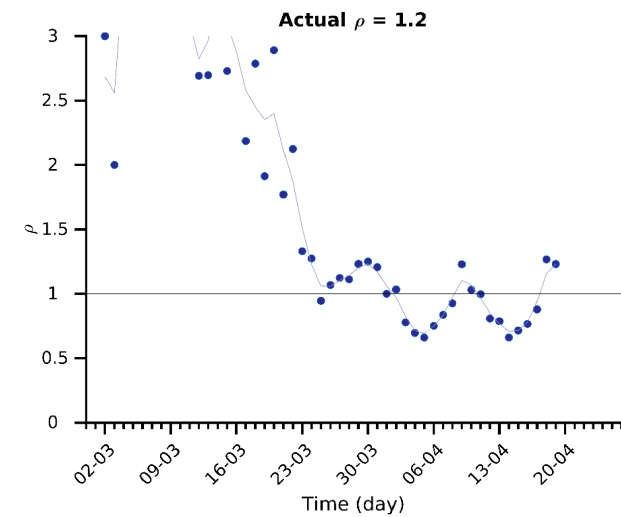
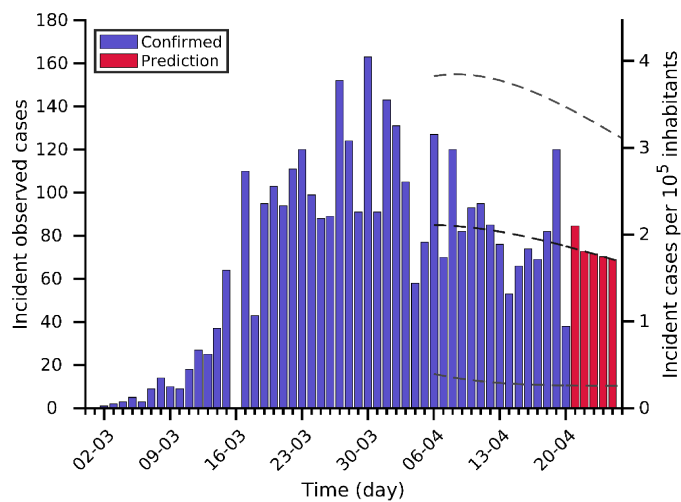
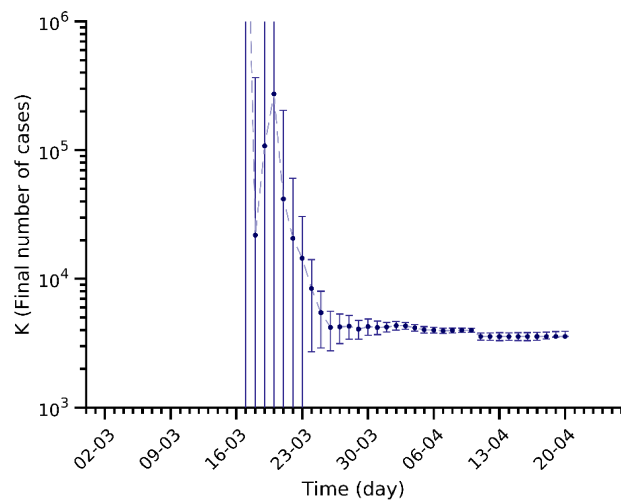
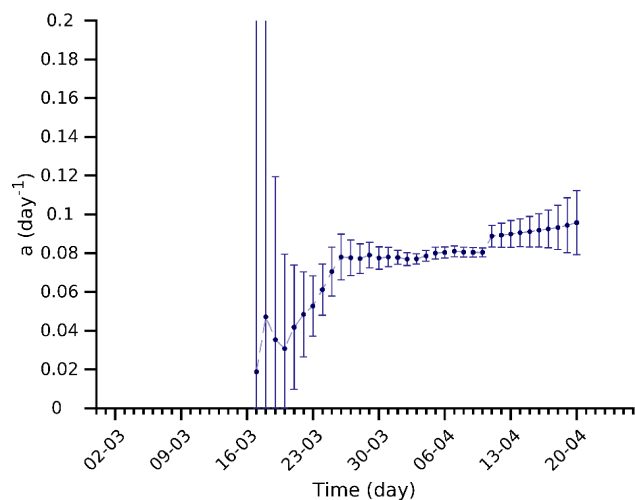
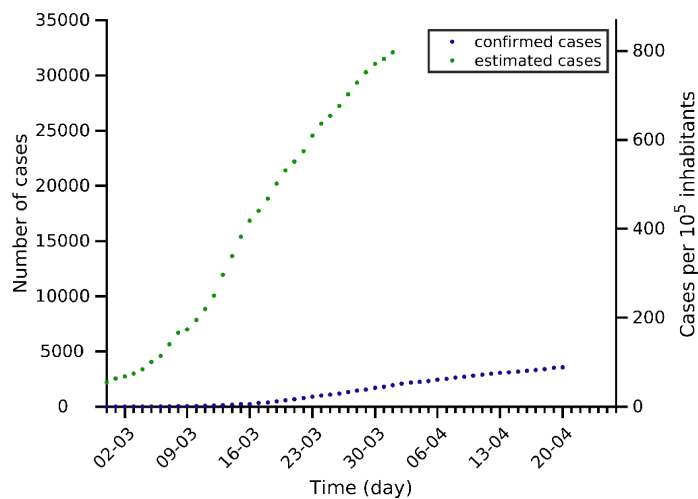
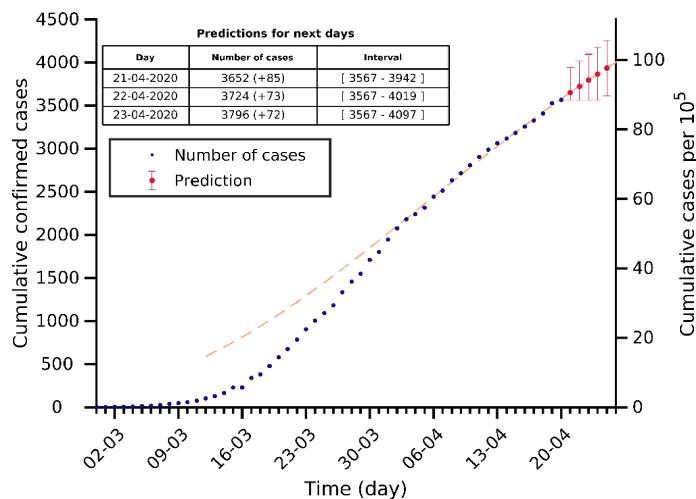
Campania 20-04-2020. Population: 5.8M. Current cumulated incidence: 70/10⁵



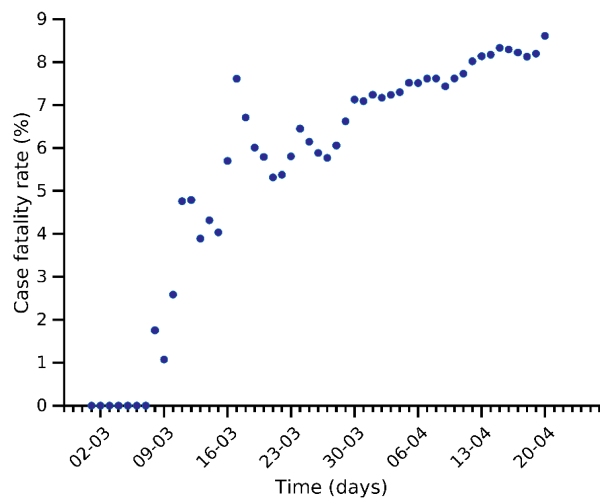
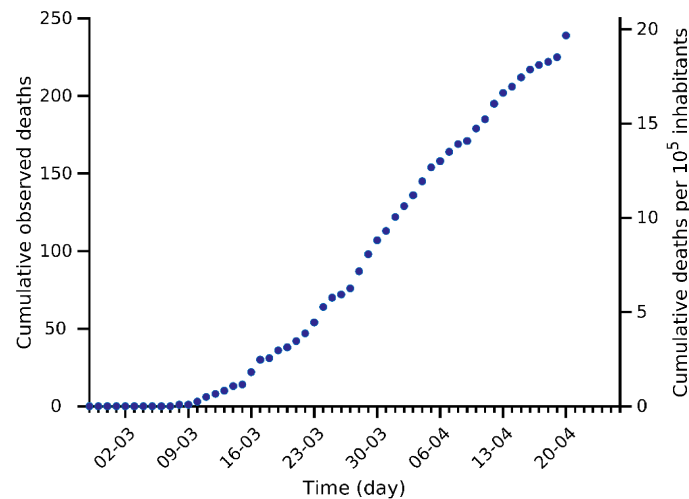
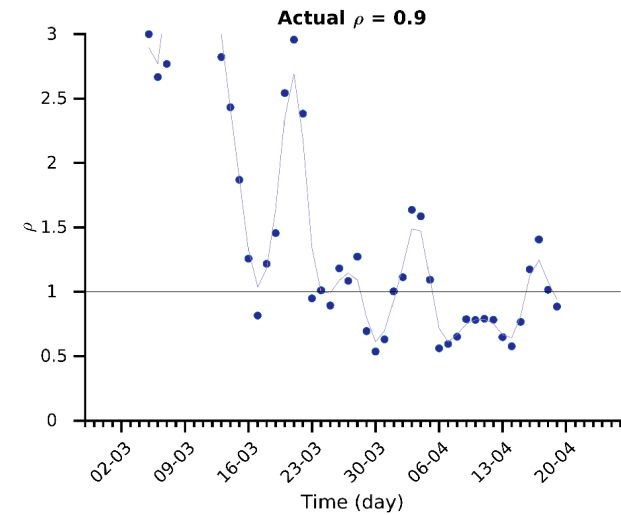
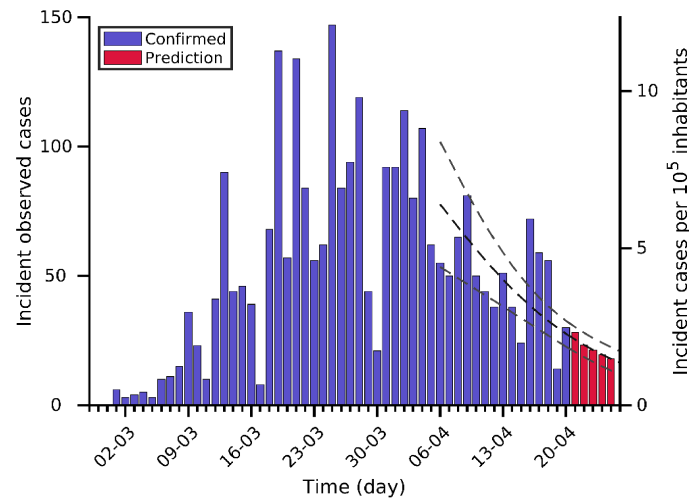
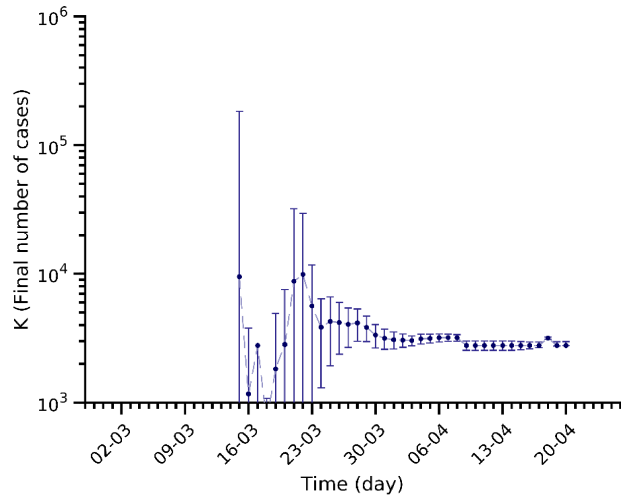
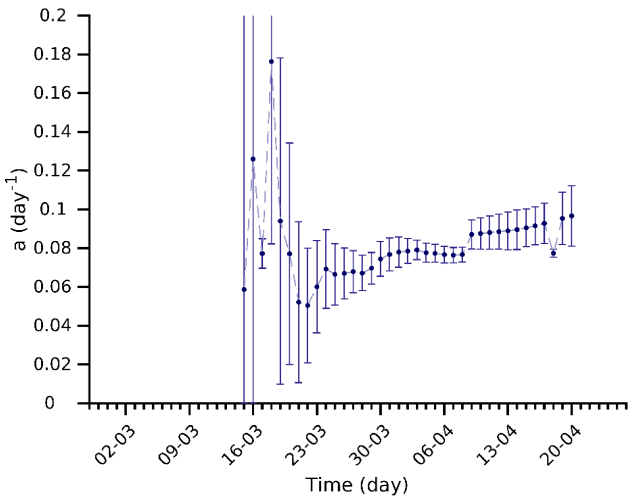
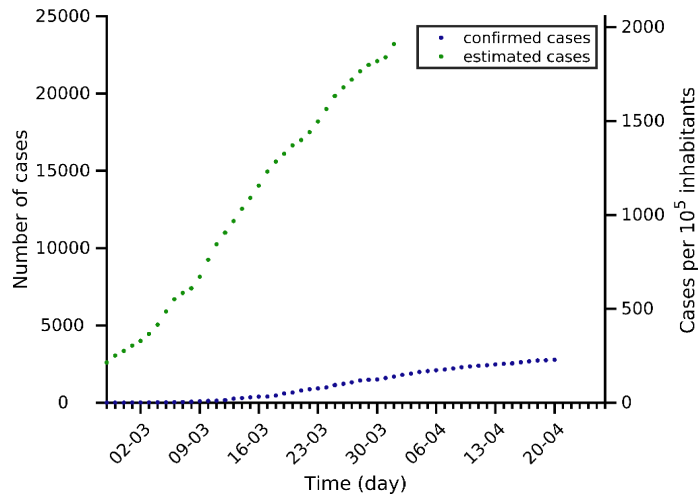
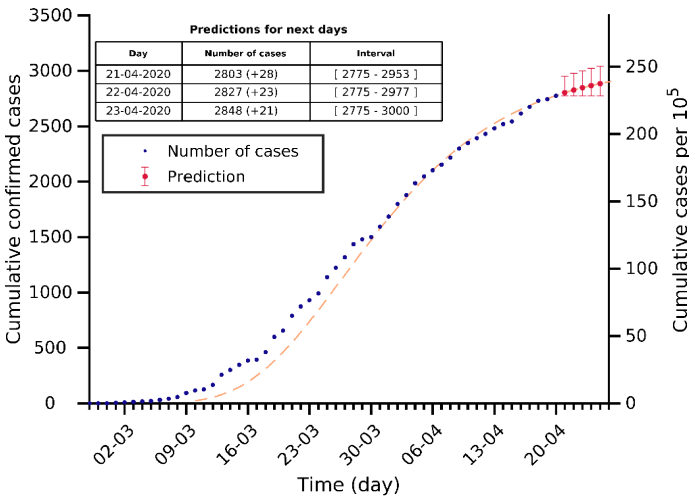
Trento 20-04-2020. Population: 0.5M. Current cumulated incidence: 667/10⁵



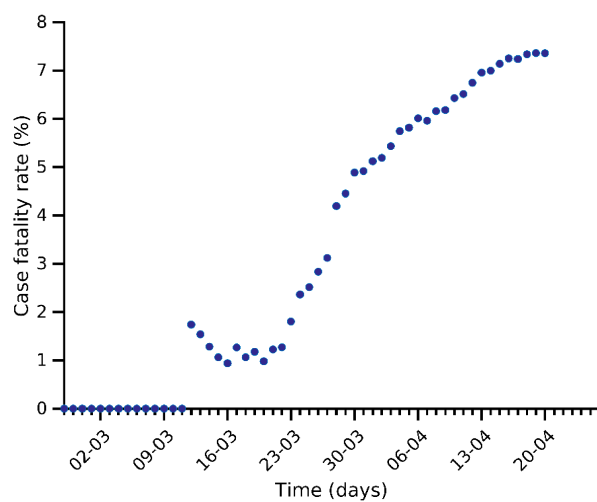
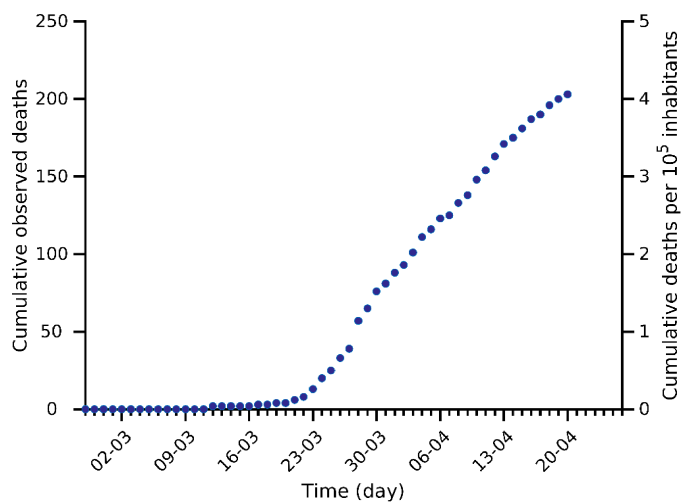
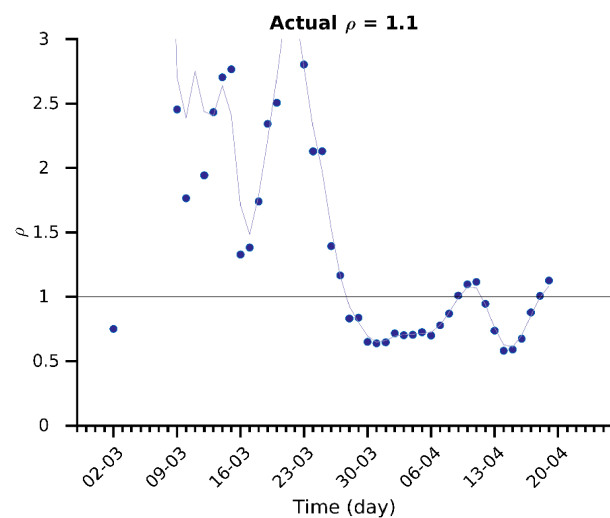
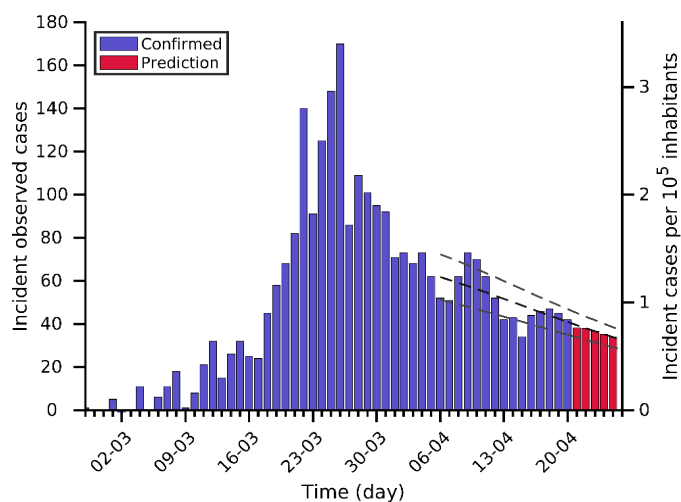
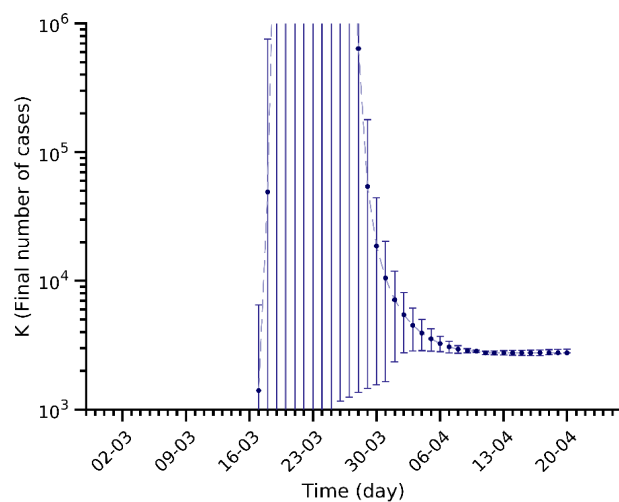
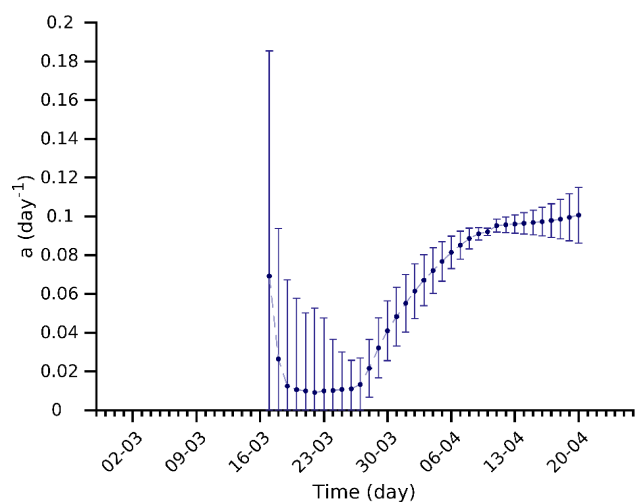
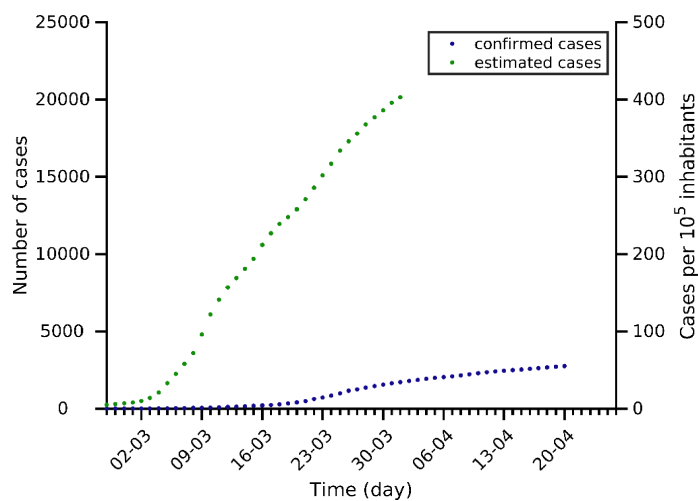
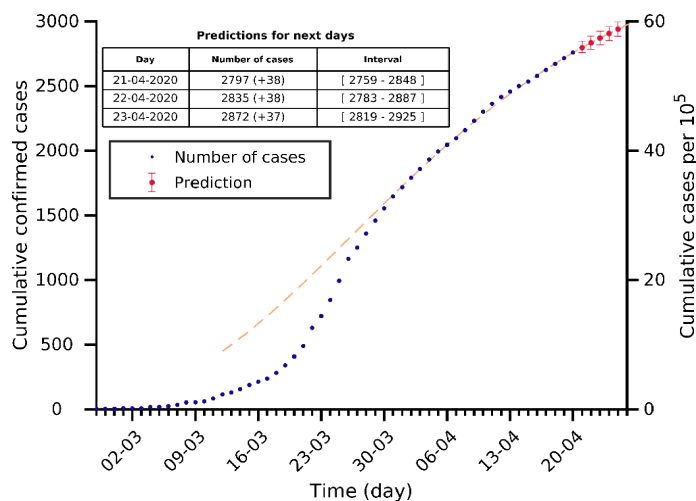
Puglia 20-04-2020. Population: 4.0M. Current cumulated incidence: 89/10⁵



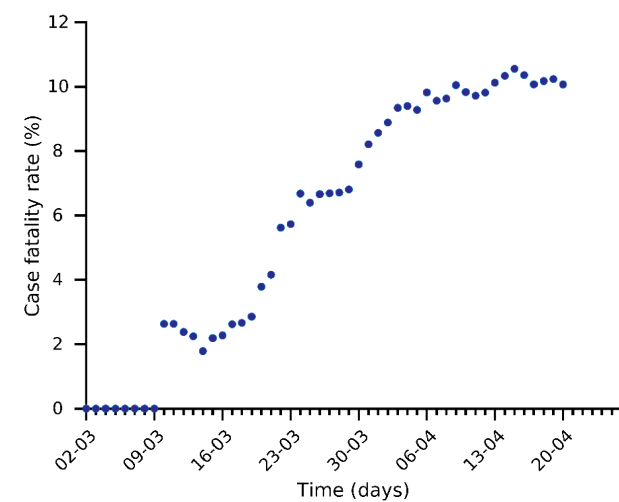
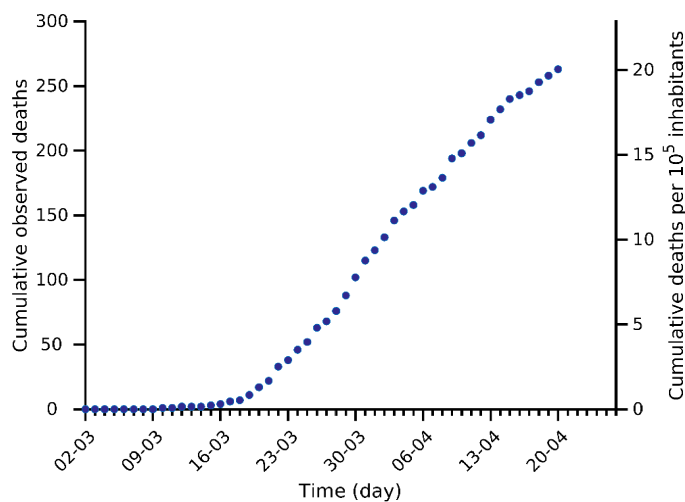
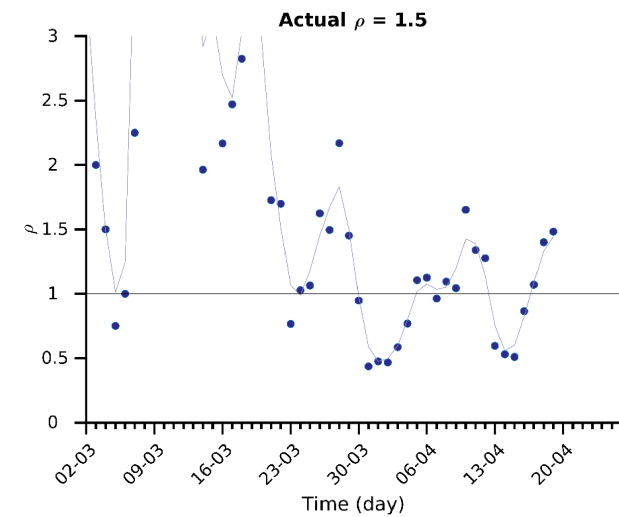
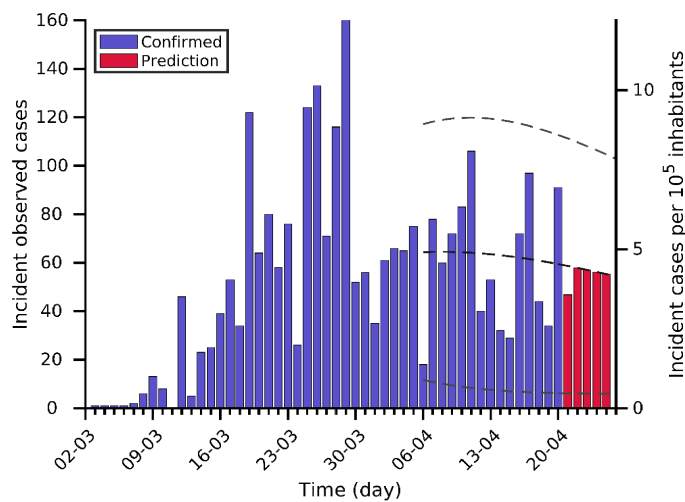
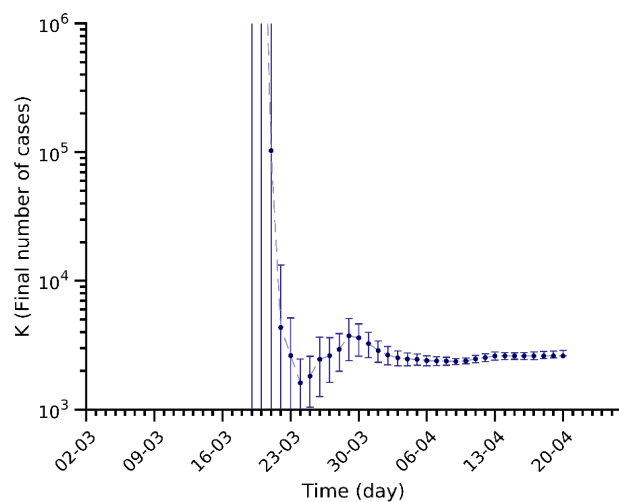
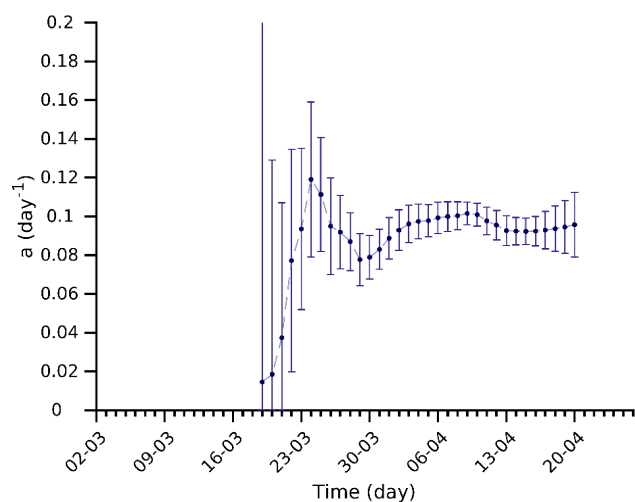
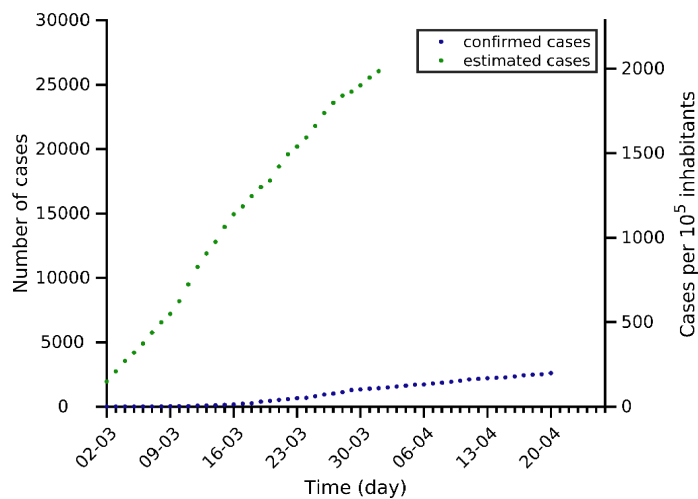
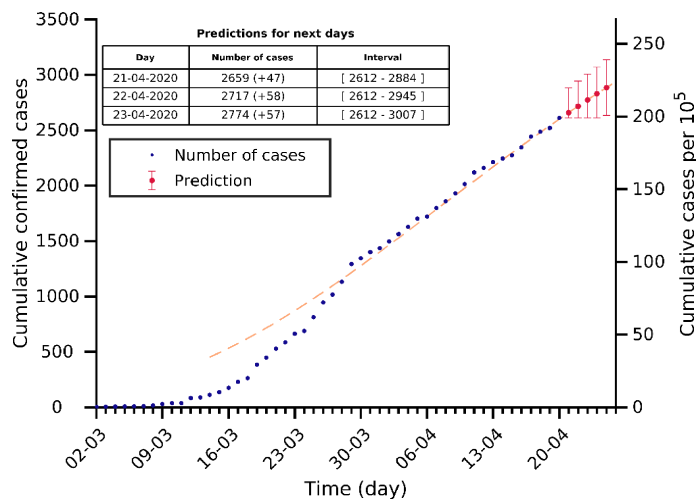
Friuli Venezia Giulia 20-04-2020. Population: 1.2M. Current cumulated incidence: 2



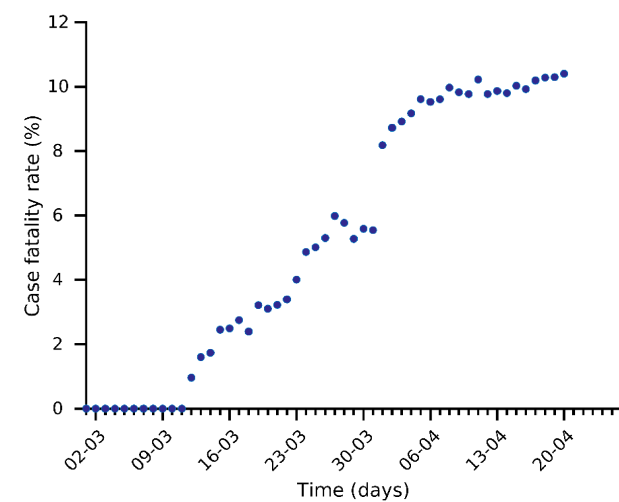
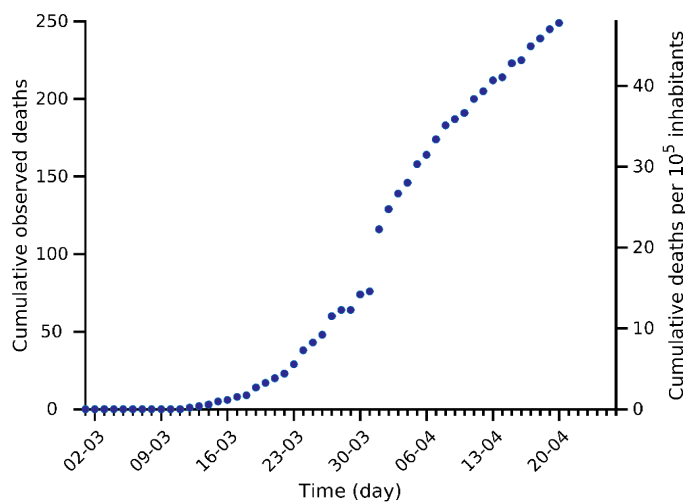
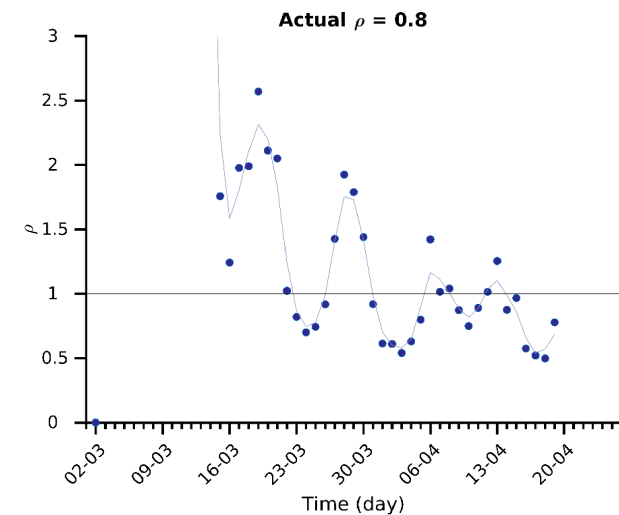
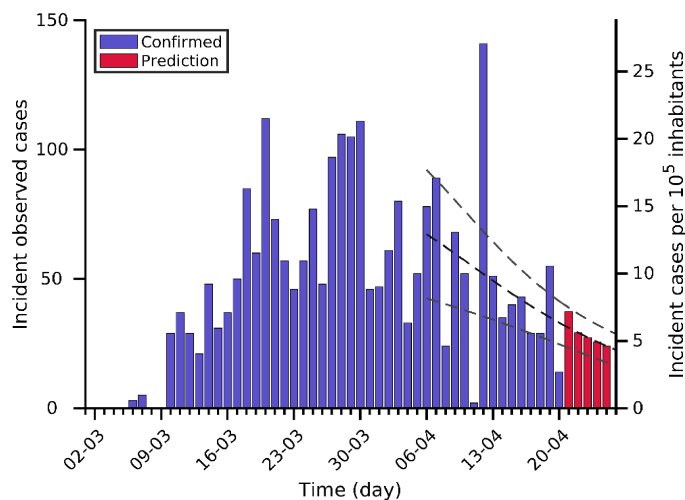
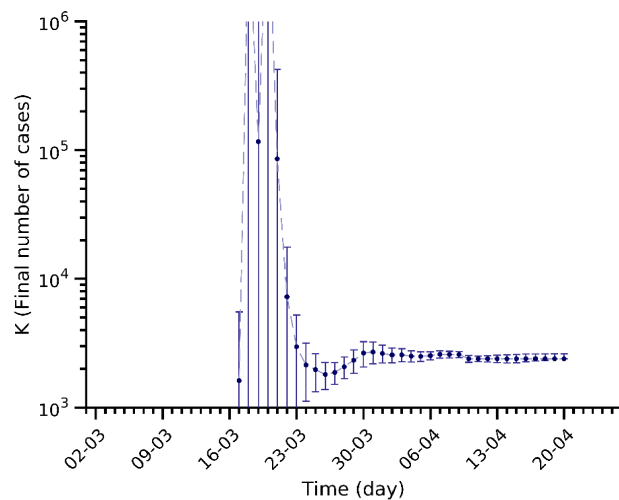
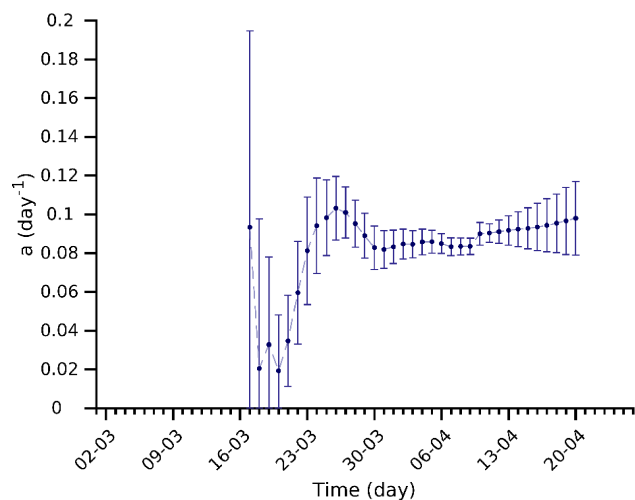
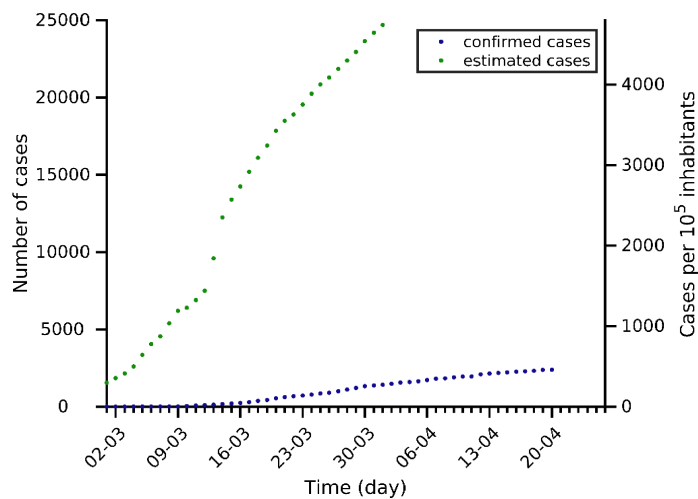
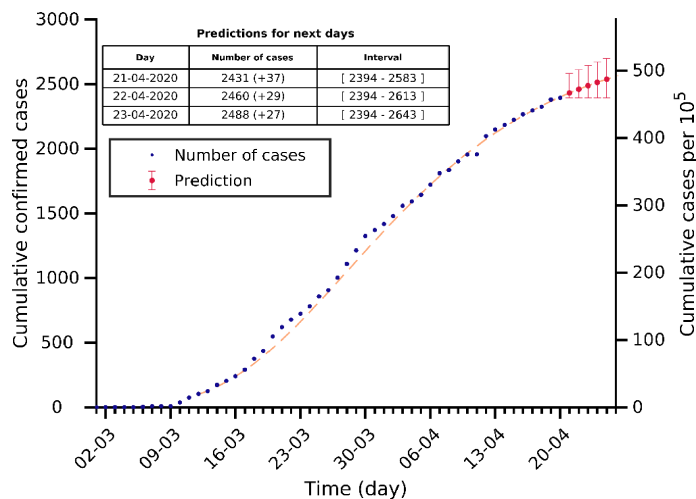
Sicilia 20-04-2020. Population: 5.0M. Current cumulated incidence: 55/10⁵



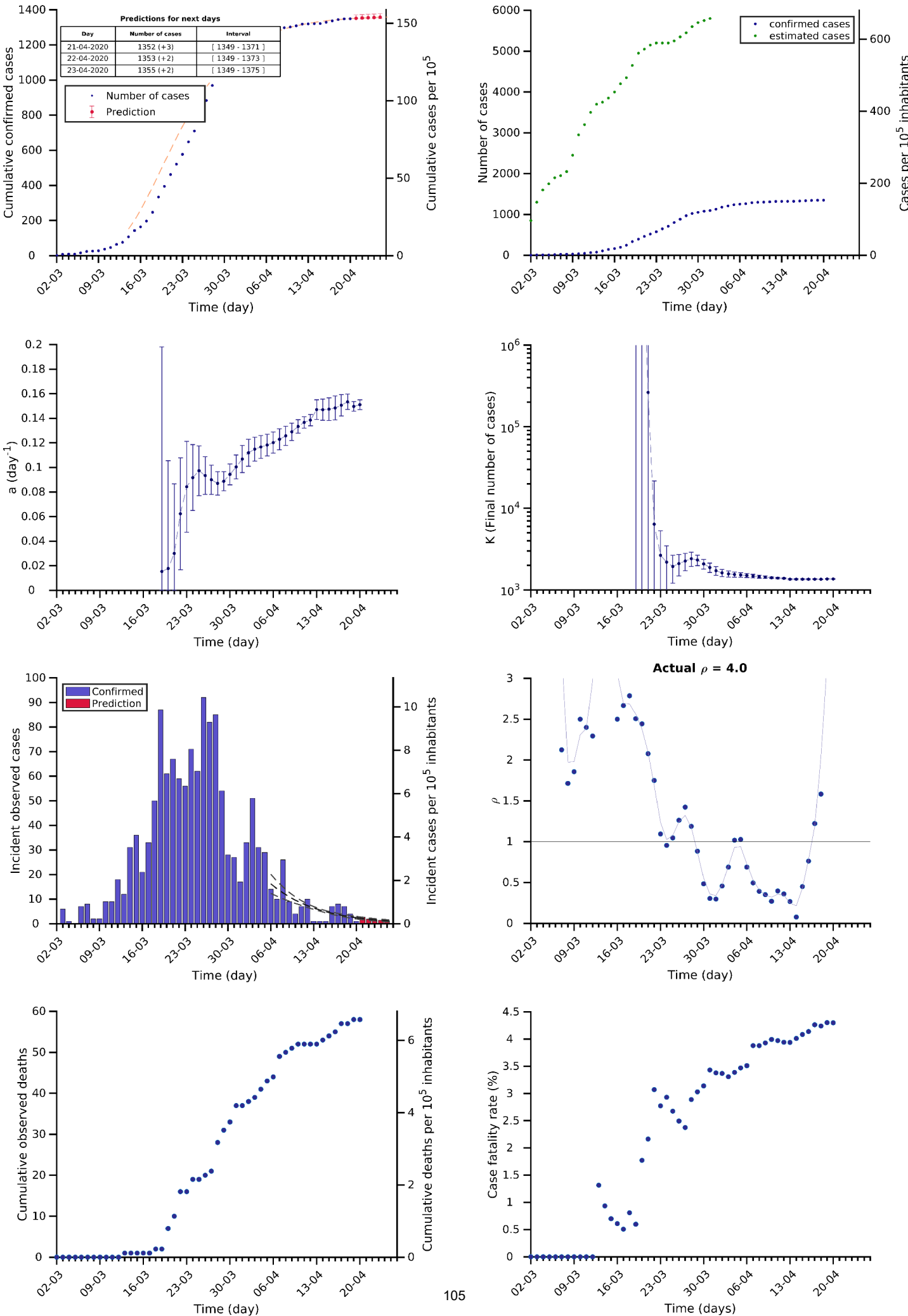
Abruzzo 20-04-2020. Population: 1.3M. Current cumulated incidence: 199/10⁵



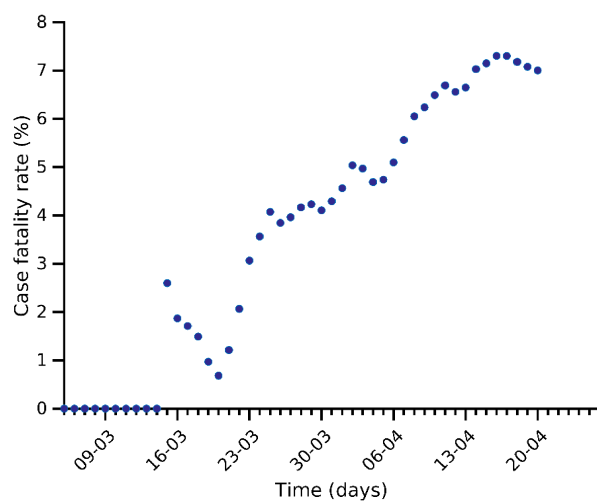
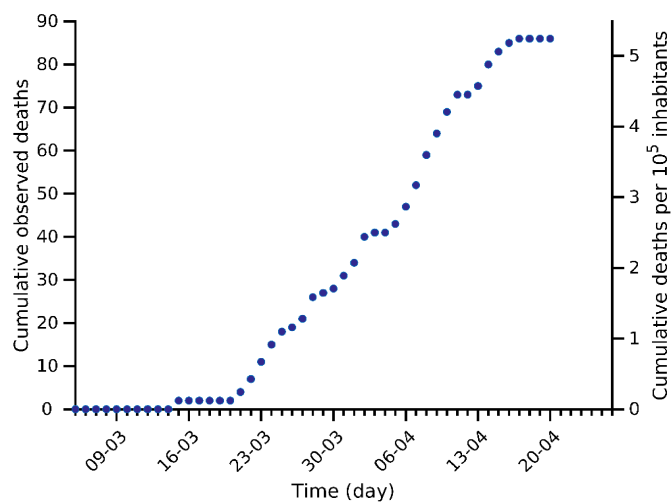
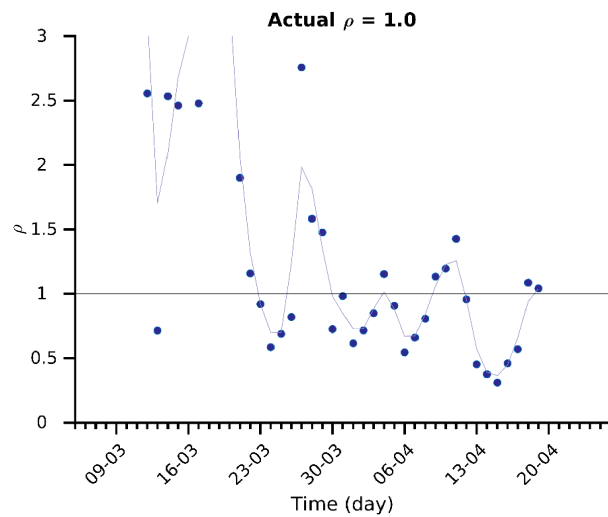
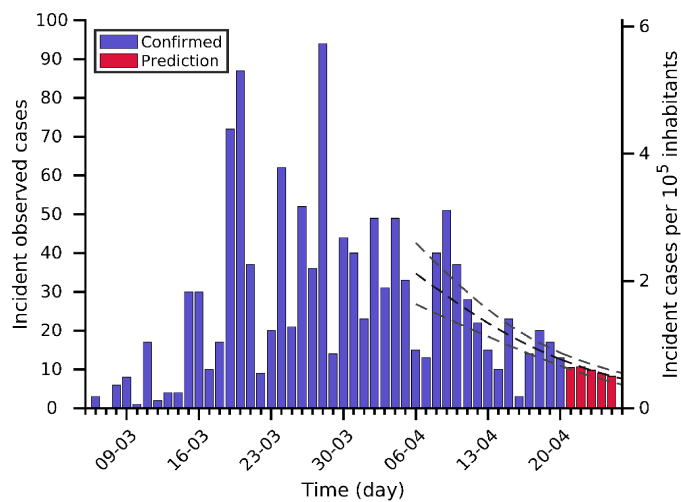
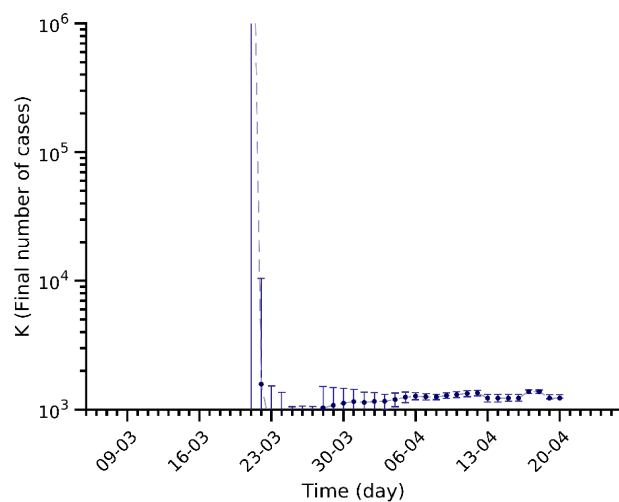
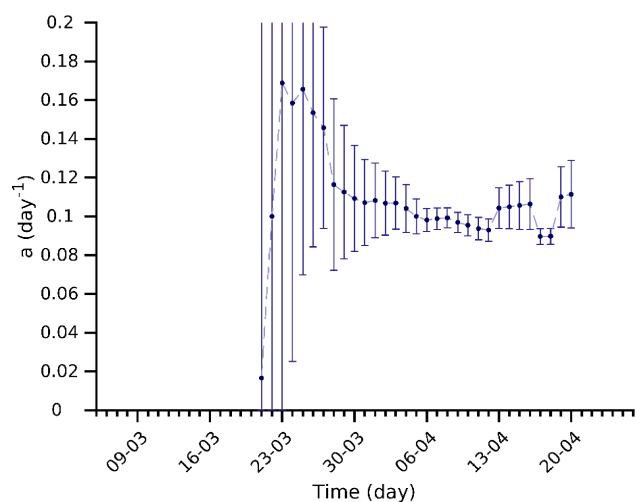
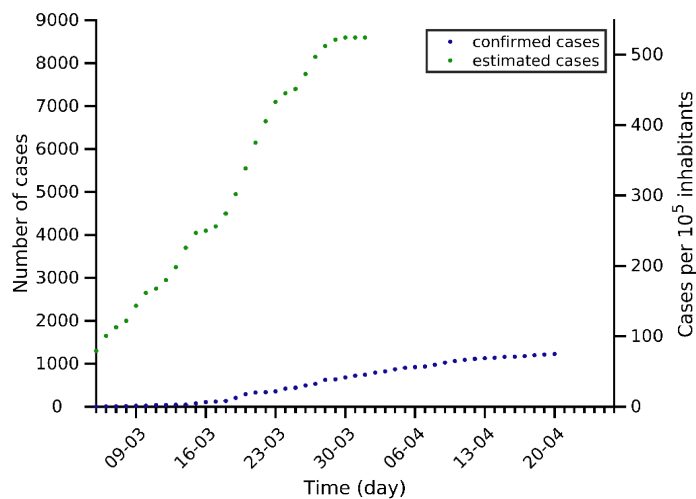
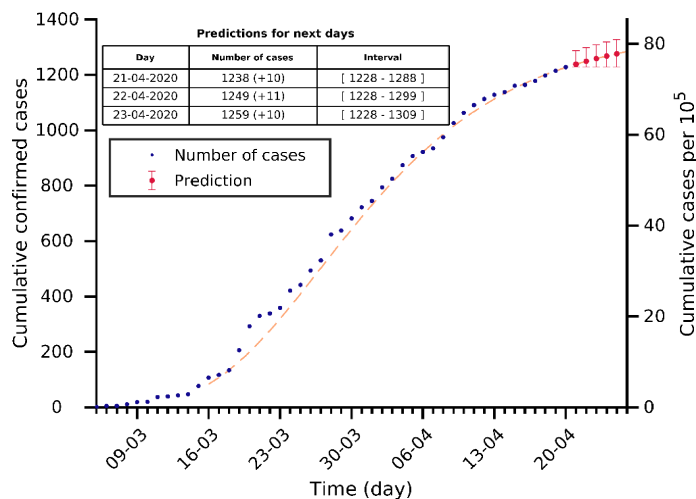
Bolzano 20-04-2020. Population: 0.5M. Current cumulated incidence: 460/10⁵



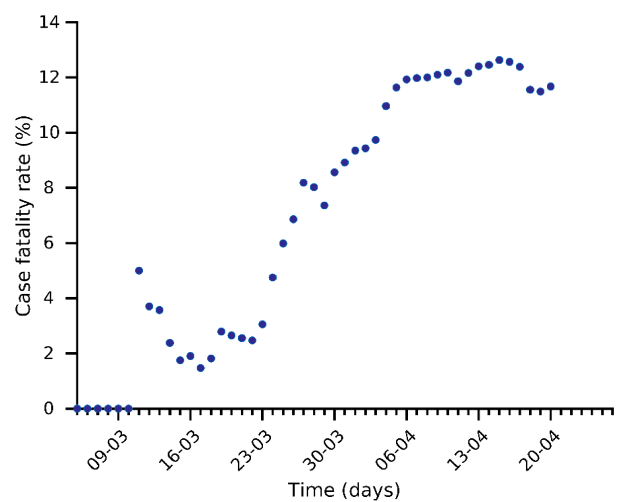
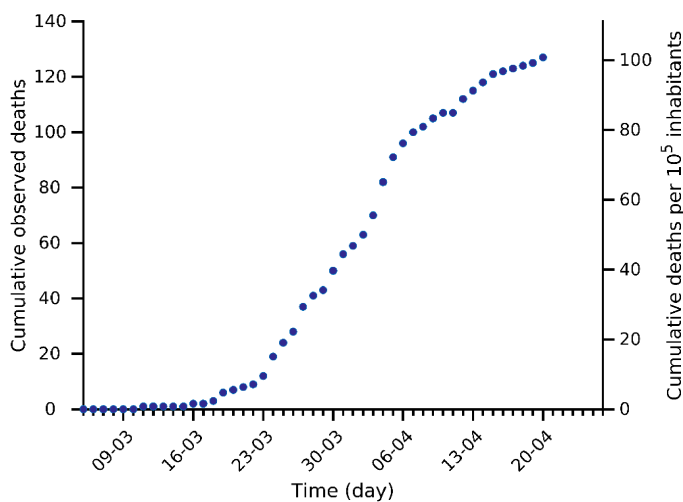
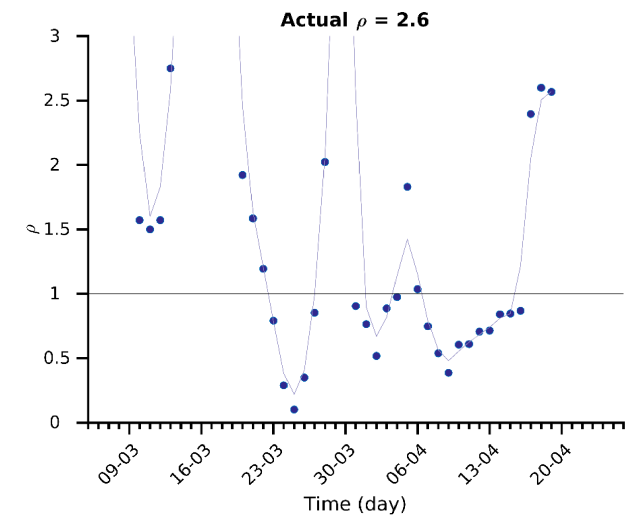
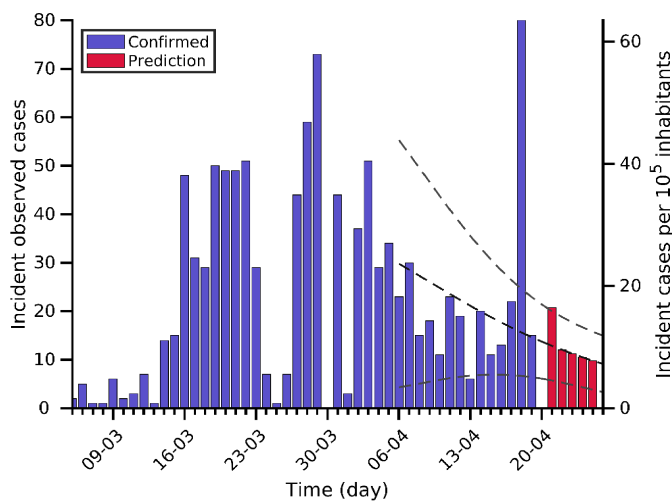
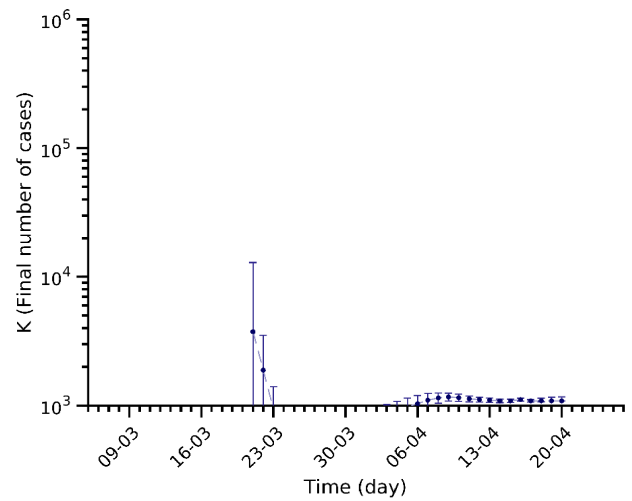
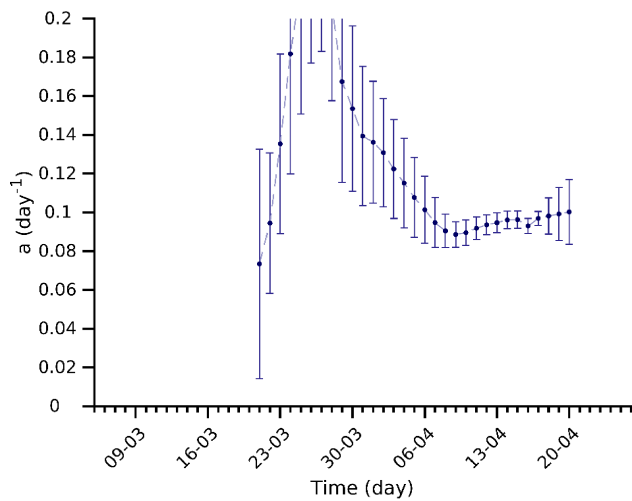
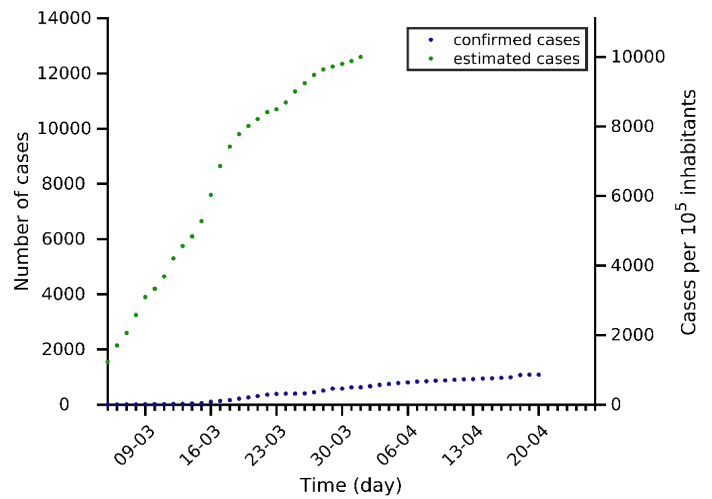
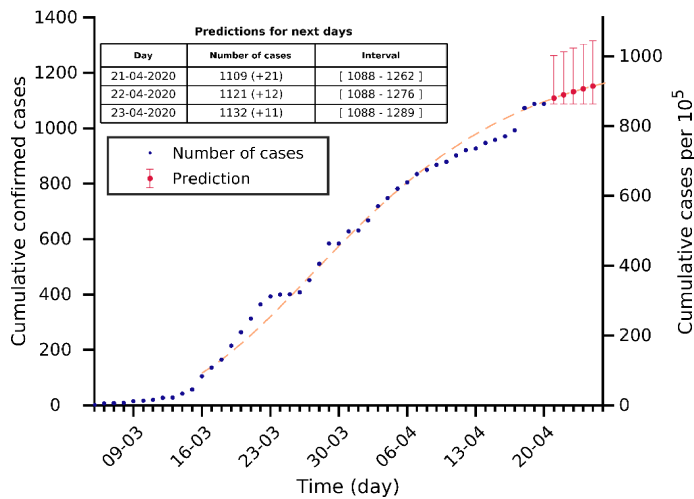
Umbria 20-04-2020. Population: 0.9M. Current cumulated incidence: 153/10⁵



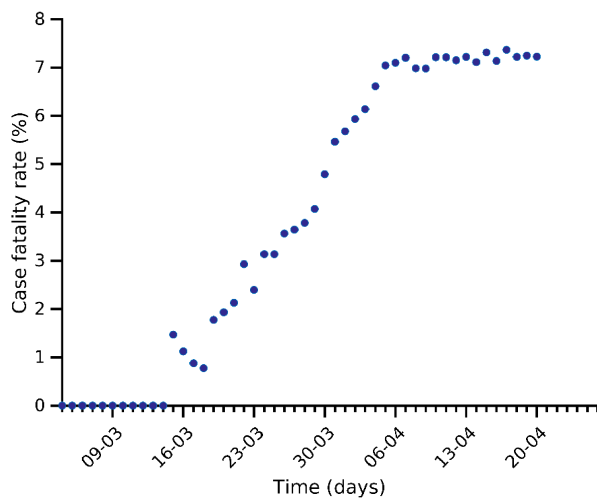
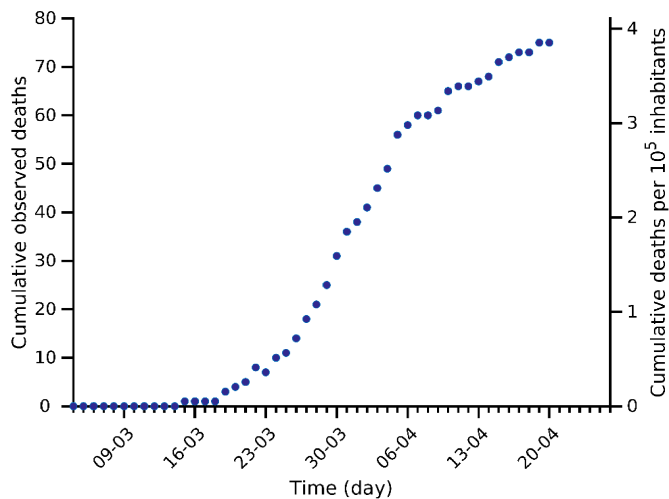
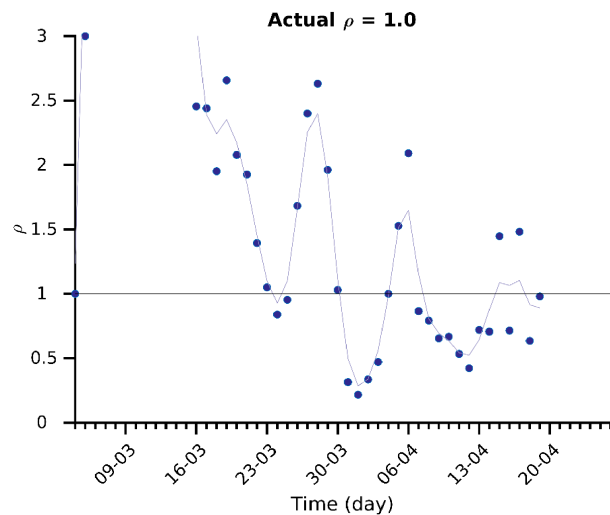
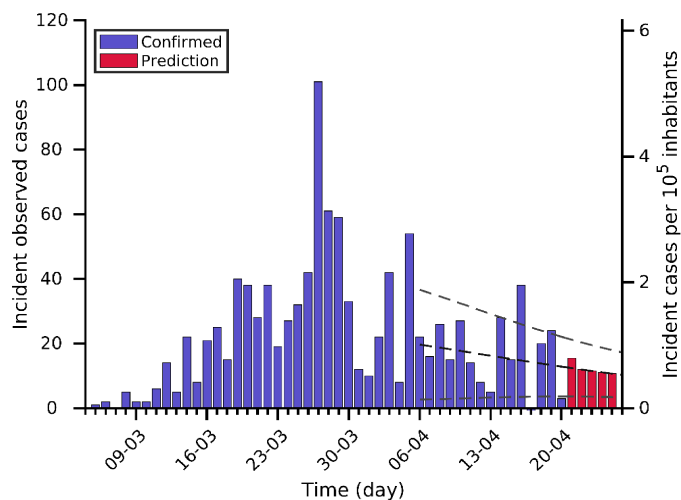
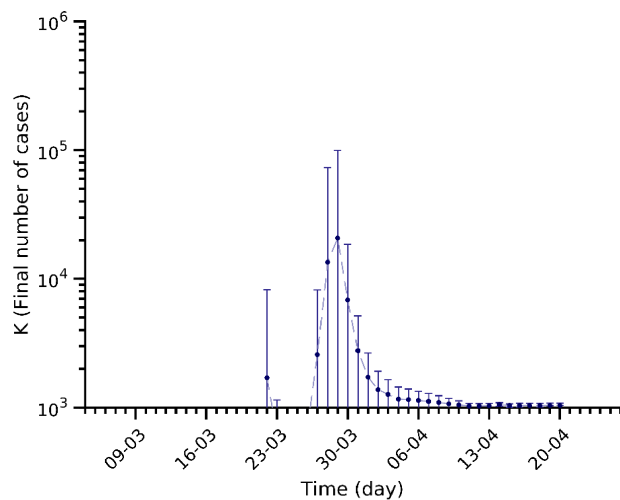
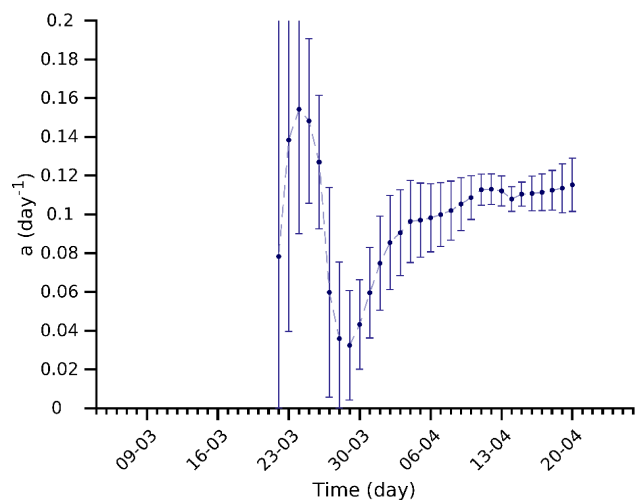
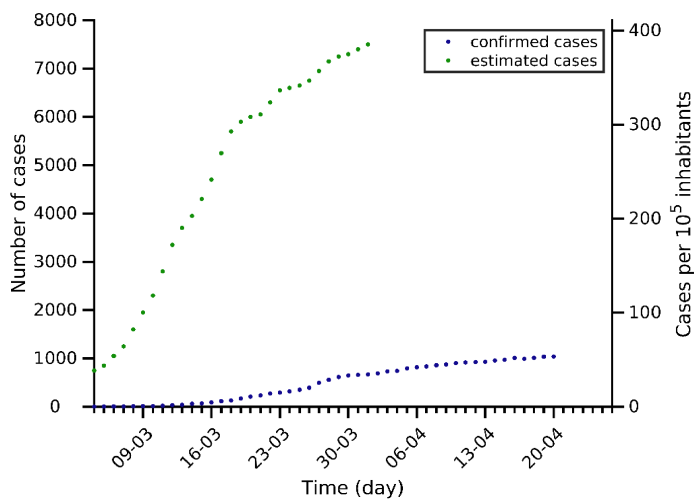
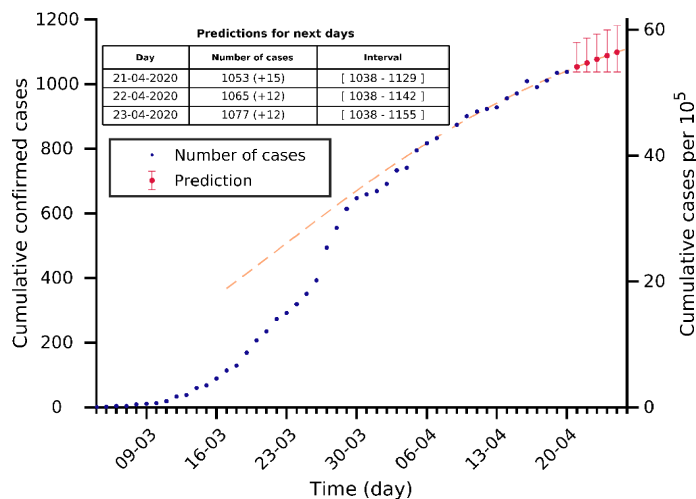
Sardegna 20-04-2020. Population: 1.6M. Current cumulated incidence: 75/10⁵



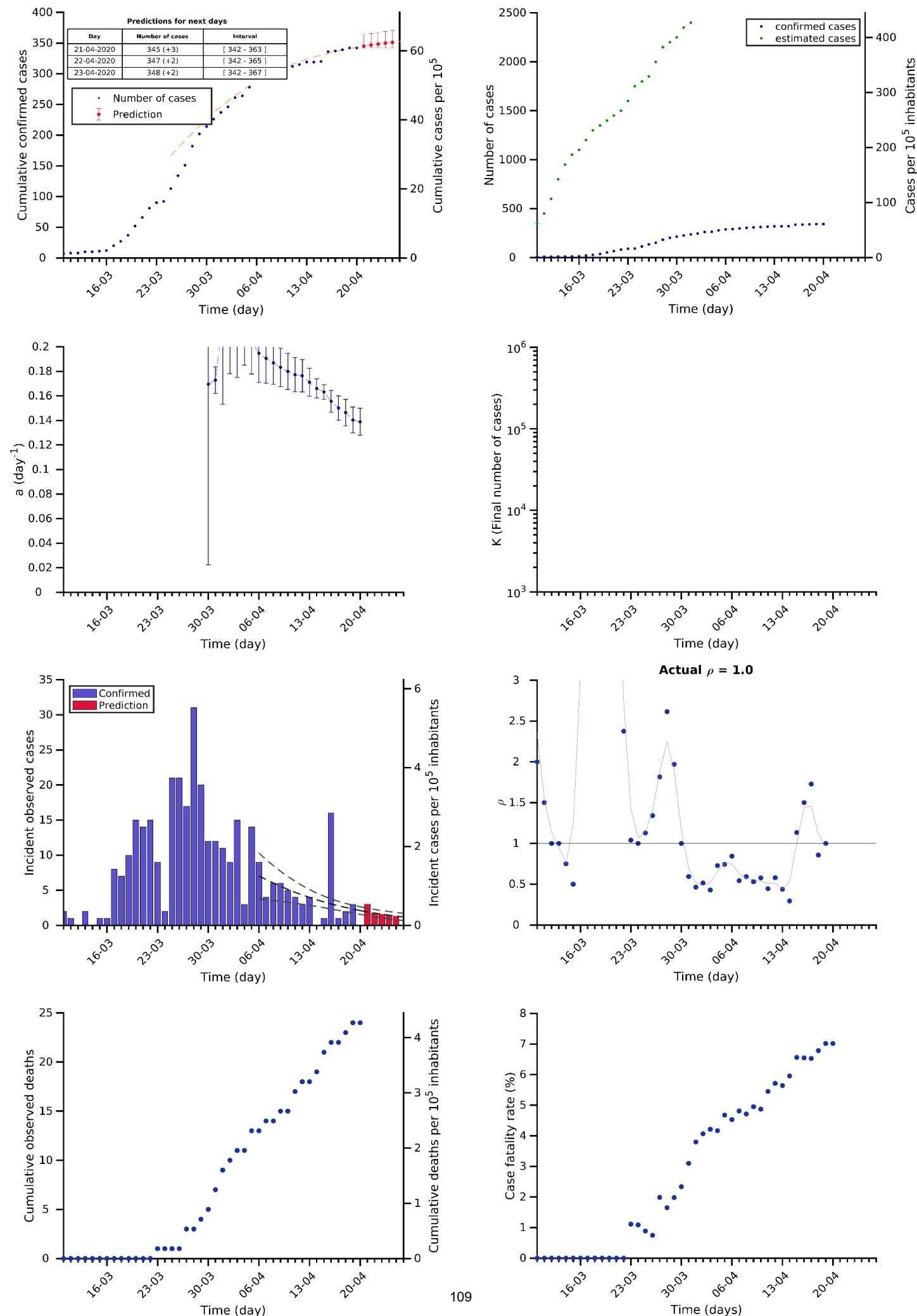
Valle d'Aosta 20-04-2020. Population: 0.1M. Current cumulated incidence: 863/10⁵



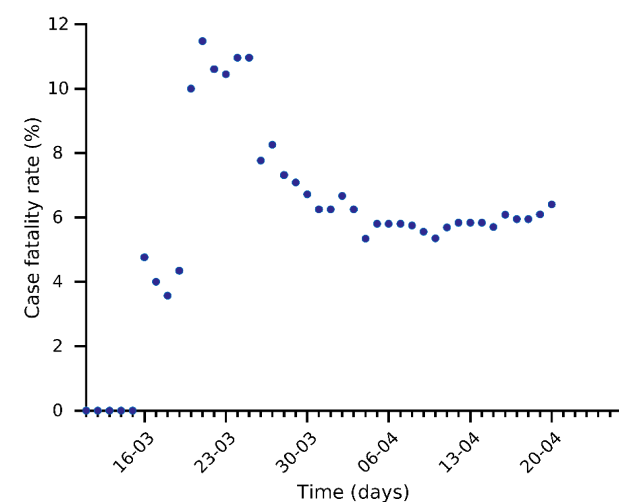
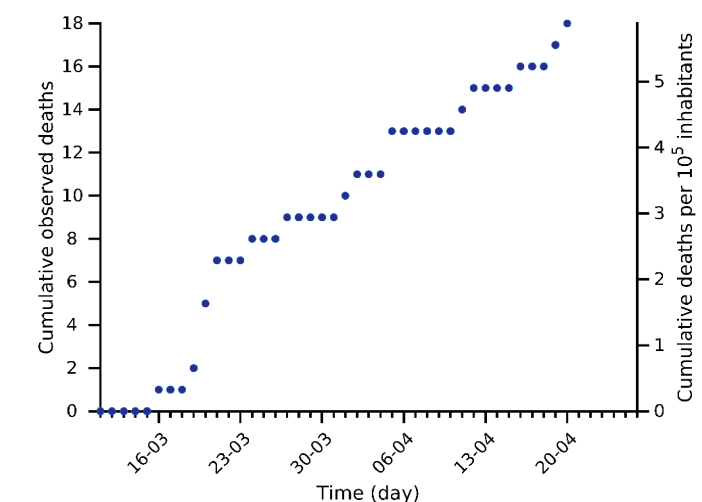
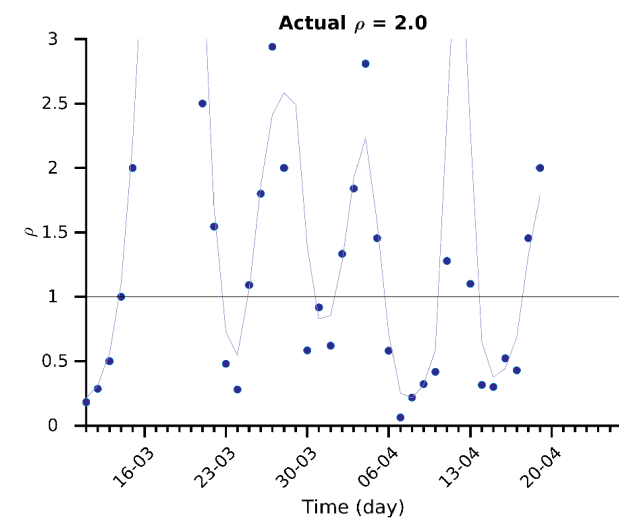
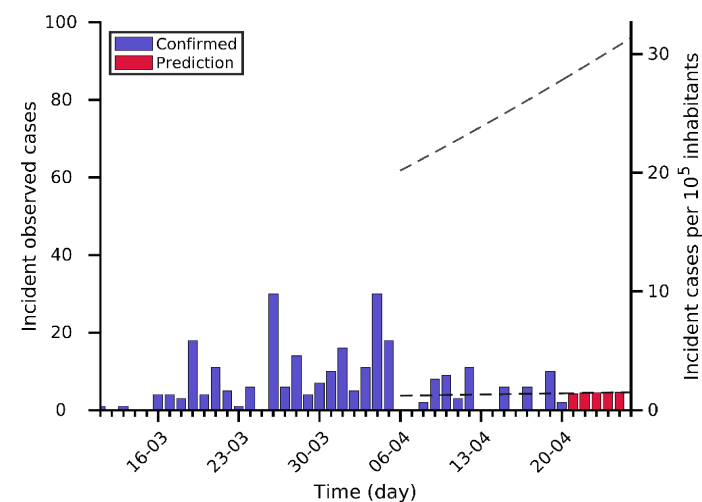
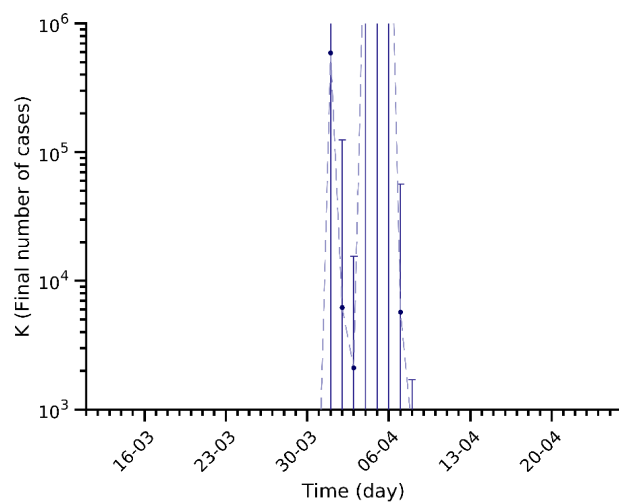
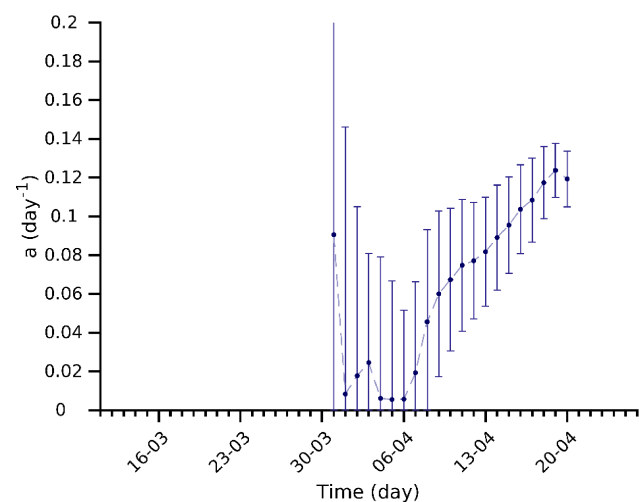
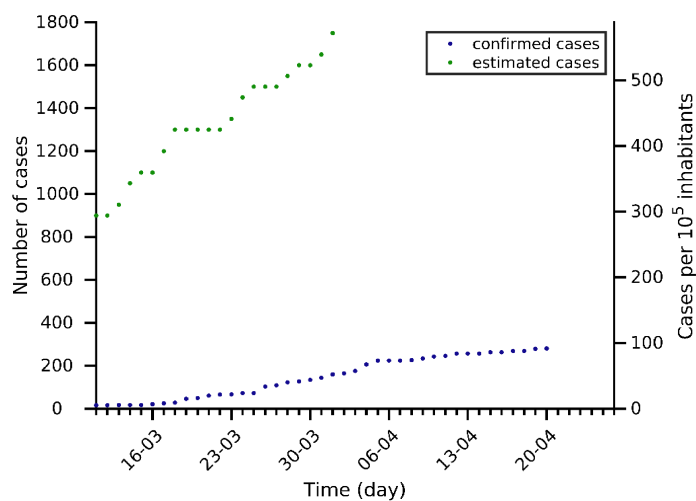
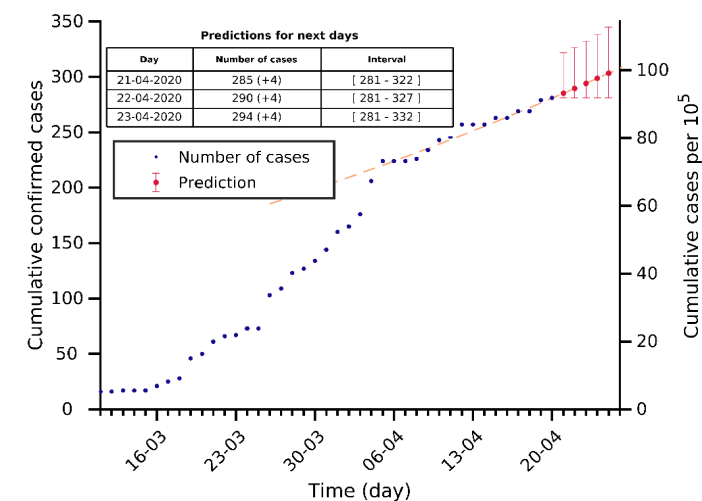
Calabria 20-04-2020. Population: 1.9M. Current cumulated incidence: 53/10⁵



Basilicata 20-04-2020. Population: 0.6M. Current cumulated incidence: 61/10⁵



Molise 20-04-2020. Population: 0.3M. Current cumulated incidence: 92/10⁵



Methods

Methods

(1) Data source

Data are daily obtained from World Health Organization (WHO) surveillance reports¹, from European Centre for Disease Prevention and Control (ECDC)² and from Ministerio de Sanidad³. These reports are converted into text files that can be processed for subsequent analysis. Daily data comprise, among others: total confirmed cases, total confirmed new cases, total deaths, total new deaths. It must be considered that the report is always providing data from previous day. In the document we use the date at which the datapoint is assumed to belong, i.e., report from 15/03/2020 is giving data from 14/03/2020, the latter being used in the subsequent analysis.

(2) Data processing and plotting

Data are initially processed with Matlab in order to update timeseries, i.e., last datapoints are added to historical sequences. These timeseries are plotted for EU individual countries and for the UE as a whole:

- ✓ Number of cumulated confirmed cases, in blue dots
- ✓ Number of reported new cases
- ✓ Number of cumulated deaths

Then, two indicators are calculated and plotted, too:

- ✓ Number of cumulated deaths divided by the number of cumulated confirmed cases, and reported as a percentage; it is an indirect indicator of the diagnostic level.
- ✓ ρ : this variable is related with the reproduction number, i.e., with the number of new infections caused by a single case. It is evaluated as follows for the day before last report ($t-1$):

$$\rho(t-1) = \frac{N_{new}(t) + N_{new}(t-1) + N_{new}(t-2)}{N_{new}(t-5) + N_{new}(t-6) + N_{new}(t-7)}$$

where $N_{new}(t)$ is the number of new confirmed cases at day t .

(3) Classification of countries according to their status in the epidemic cycle

The evolution of confirmed cases shows a biphasic behaviour:

- (I) an initial period where most of the cases are imported;
- (II) a subsequent period where most of new cases occur because of local transmission.

Once in the stage II, mathematical models can be used to track evolutions and predict tendencies. Focusing on countries that are on stage II, we classify them in three groups:

- Group A: countries that have reported more than 100 cumulated cases for 10 consecutive days or more;
- Group B: countries that have reported more than 100 cumulated cases for 7 to 9 consecutive days;
- Group C: countries that have reported more than 100 cumulated cases for 4 to 6 days.

¹ <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/situation-reports>

² <https://www.ecdc.europa.eu/en/geographical-distribution-2019-ncov-cases>

³ <https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/situacionActual.htm>
<https://github.com/datadista/datasets/tree/master/COVID%2019>

(4) Fitting a mathematical model to data

Previous studies have shown that Gompertz model⁴ correctly describes the Covid-19 epidemic in all analysed countries. It is an empirical model that starts with an exponential growth but that gradually decreases its specific growth rate. Therefore, it is adequate for describing an epidemic that is characterized by an initial exponential growth but a progressive decrease in spreading velocity provided that appropriate control measures are applied.

Gompertz model is described by the equation:

$$N(t) = K e^{-\ln\left(\frac{K}{N_0}\right) \cdot e^{-a \cdot (t-t_0)}}$$

where $N(t)$ is the cumulated number of confirmed cases at t (in days), and N_0 is the number of cumulated cases the day at day t_0 . The model has two parameters:

- ✓ a is the velocity at which specific spreading rate is slowing down;
- ✓ K is the expected final number of cumulated cases at the end of the epidemic.

This model is fitted to reported cumulated cases of the UE and of countries in stage II that accomplish two criteria: 4 or more consecutive days with more than 100 cumulated cases, and at least one datapoint over 200 cases. Day t_0 is chosen as that one at which $N(t)$ overpasses 100 cases. If more than 15 datapoints that accomplish the stated criteria are available, only the last 15 points are used. The fitting is done using Matlab's Curve Fitting package with Nonlinear Least Squares method, which also provides confidence intervals of fitted parameters (a and K) and the R^2 of the fitting. At the initial stages the dynamics is exponential and K cannot be correctly evaluated. In fact, at this stage the most relevant parameter is a . Fitted curves are incorporated to plots of cumulative reported cases with a dashed line. Once a new fitting is done, two plots are added to the country report:

- ✓ Evolution of fitted a with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out;
- ✓ Evolution of fitted K with its error bars, i.e., values obtained on the fitting each day that the analysis has been carried out; if lower error bar indicates a value that is lower than current number of cases, the error bar is truncated.

These plots illustrate the increase in fittings' confidence, as fitted values progressively stabilize around a certain value and error bars get smaller when the number of datapoints increases. In fact, in the case of countries, they are discarded and set as "Not enough data" if $a > 0.2 \text{ day}^{-1}$, if $K > 10^6$ or if the error in K overpasses 10^6 .

It is worth to mention that the simplicity of this model and the lack of previous assumptions about the Covid-19 behaviour make it appropriate for universal use, i.e., it can be fitted to any country independently of its socioeconomic context and control strategy. Then, the model is capable of quantifying the observed dynamics in an objective and standard manner and predicting short-term tendencies.

(5) Using the model for predicting short-term tendencies

The model is finally used for a short-term prediction of the evolution of the cumulated number of cases. The predictions increase their reliability with the number of datapoints used in the fitting. Therefore, we consider three levels of prediction, depending on the country:

⁴ Madden LV. Quantification of disease progression. *Protection Ecology* 1980; **2**: 159-176.

- Group A: prediction of expected cumulated cases for the following 3-5 days⁵;
- Group B: prediction of expected cumulated cases for the following 2 days;
- Group C: prediction of expected cumulated cases for the following day.

The confidence interval of predictions is assessed with the Matlab function `predint`, with a 99% confidence level. These predictions are shown in the plots as red dots with corresponding error bars, and also gathered in the attached table. For series longer than 9 timepoints, last 3 points are weighted in the fitting so that changes in tendencies are well captured by the model.

(6) Estimating non-diagnosed cases

Lethality of Covid-19 has been estimated at around 1 % for Republic of Korea and the Diamond Princess cruise. Besides, median duration of viral shedding after Covid-19 onset has been estimated at 18.5 days for non-survivors⁶ in a retrospective study in Wuhan. These data allow for an estimation of total number of cases, considering that the number of deaths at certain moment should be about 1 % of total cases 18.5 days before. This is valid for estimating cases of countries at stage II, since in stage I the deaths would be mostly due to the incidence at the country from which they were imported. We establish a threshold of 50 reported cases before starting this estimation.

Reported deaths are passed through a moving average filter of 5 points in order to smooth tendencies. Then, the corresponding number of cases is found assuming the 1 % lethality. Finally, these cases are distributed between 18 and 19 days before each one.

⁵ At this moment we are testing predictions at 4 days for countries with more than 100 cumulated cases for 13-15 consecutive days, and 5 days for 16 or more days.

⁶ Zhou et al., 2020. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. The Lancet; March 9, doi: 10.1016/S0140-6736(20)30566-3